RELIABILITY ABSTRACTS and TECHNICAL REVIEWS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Office of Reliability and Quality Assurance
Washington, D.C. 20546

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Abstracts 1696–2377

PREFACE

In order to help scientists concerned with the reliability of parts, assemblies, components, and systems to stay abreast of the latest developments in the literature in this field, the National Aeronautics and Space Administration has since April 1961 sponsored the production of RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS. Volume 5 contains Serial Numbers 1696-2377, issued during the year 1965. The contents of the previous volumes are as follows:

First, Serial Numbers 1-275 issued between April 1961 and May 1962
Second, Serial Numbers 276-775 issued between June 1962 and May 1963
Third, Serial Numbers 776-1305 issued between June 1963 and May 1964
Fourth, Serial Numbers 1306-1695 issued between June 1964 and December 1964.

The work on this project is performed by the Research Triangle Institute, Durham, North Carolina under the sponsorship and supervision of the Office of Reliability and Quality Assurance of NASA. Current papers on reliability and closely related subjects are sought from all available sources, including technical journals, trade magazines, and proceedings of conferences and meetings. Authors of papers and technical reports in the field are invited to submit their material for inclusion in the service. Abstracts and reviews of the papers are prepared and submitted in monthly installments to NASA for distribution to a NASA mailing list. Prior to its submittal to NASA, each abstract and review is sent in draft form to the author (or first author) of the paper to enable him to make comments. The comments received are considered in preparing the final form of the abstract and review.

Each item in this volume has been classified as to subject according to the American Society for Quality Control Literature Classification System, Methodology or Techniques Classification, as revised in January 1963. A listing of the code numbers of this system, together with the subject-matter categories for which they stand, appears on page two. The codes assigned to the individual paper appear below the serial number on the corresponding abstract and review sheet, and are intended to represent not only the principal subject matter of the paper, but also areas in which the contents may be expected to be useful. To facilitate the search for material in given subject-matter categories, a listing has been prepared of the serial numbers of the papers to which the various codes have been assigned. This listing appears as the INDEX OF SERIAL NUMBERS BY CODES, on pages three through eight.

A CUMULATIVE AUTHOR INDEX for Abstract Serial Numbers 1-2377 is found on pages nine through thirty-one.

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Serial Number 1696
ASQC Codes 780;815;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Do specifications assure performance?--The Relay satellite

AUTHOR: L. Gomberg, Radio Corporation of America, Astro-Electronics Division

SOURCE: Transactions 1964 Metropolitan Conference, sponsored by Metropolitan, North Jersey, and Long Island Sections, American Society for Quality Control, New York, New York, June, 1964, pp. 1-16

PURPOSE: To describe the development of a series of specifications for the Relay satellite.

ABSTRACT: Specifications can assure performance only to the extent that the specification document is correlated with actual performance requirements. In a space program, the establishment of this correlation is not a simple task. One does not know the environment with any degree of precision, the components and parts used in the satellite may be pushing the state-of-the-art, and the number of missions or vehicles is small. As a result, the experience gained from other programs is used as a starting point.

The heart of the specification system on Project Relay was the performance requirements developed by NASA. From these, a spectrum of specifications was generated covering the areas of subsystems, black box and parts requirements. Test methods, fabrication, process, workmanship, environmental documents and drawings were prepared.

Specification organization and specification formats are described. The environmental testing program is outlined. The improvement in reliability through the use of redundancy techniques is illustrated. Finally, the spacecraft and some of its systems are described. (Author in part)

REVIEW: This is a sketch of an approach taken in developing a set of specifications for a new system, on the basis of very limited prior knowledge regarding the environmental conditions to be expected. Some details are given in tables at the end of the paper. As the author has emphasized, the key to success in any such approach lies in the extent to which the specifications correlate with the actual mission requirements, and the effectiveness of the quality control system in ensuring conformance with the specifications. ##

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Serial Number 1697
ASQC Codes 710;780

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Environmental aspects of the Telstar program

AUTHOR: T. B. Delchamps, Bell Telephone Laboratories, Inc., Whippany, New Jersey

SOURCE: Transactions 1964 Metropolitan Conference, sponsored by Metropolitan, North Jersey, and Long Island Sections, American Society for Quality Control, New York, New York, June, 1964, pp. 17-31

PURPOSE: To describe the considerations which guided the planning and execution of environmental tests in the development, design-qualification, and flight-acceptance phases of the Telstar program.

ABSTRACT: Among the many factors essential to success in equipment development are: sound basic design, discriminate selection of materials and components, and careful fabrication. Effective environmental planning and evaluation, a fourth and equally-vital ingredient of program success, serves to influence and to measure the degree to which the first three goals are met. To accomplish this, the environmental program must operate in depth in all phases of the design and development effort, making maximum use of available data, and applying judicious estimates beyond the boundaries of existing knowledge.

This paper describes the test-evaluation phase of the Telstar program, reviews sources of environmental data used to establish test levels, discusses philosophy and execution of the test program, and correlates particular laboratory results with data received from orbit. Certain related design considerations, of special interest from an environmental standpoint, are also briefly covered. (Author in part)

REVIEW: This paper illustrates the importance of an effective environmental program in the design and development of a spacecraft system. The Telstar program is one in which the various environmental aspects have received a good deal of attention. The principal findings in some six papers cited as references are essentially summarized in the present work. The paper should therefore be of considerable value to the designers of spacecraft systems. ##

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Serial Number 1698
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure mechanisms in metal film resistors

AUTHORS: M. E. Goldberg, IIT Research Institute, Chicago, Illinois and J. M. Schramp, Rome Air Development Center, Griffiss Air Force Base, New York, New York

SOURCE: Transactions 1964 Metropolitan Conference, sponsored by Metropolitan, North Jersey, and Long Island Sections, American Society for Quality Control, New York, New York, June, 1964, pp. 33-46

PURPOSE: To describe some of the results of failure physics investigations applied to an evaporated thin film metal alloy resistor.

ABSTRACT: The objective of the Comprehensive Failure Theory effort being conducted at IITRI is to demonstrate a path by which the knowledge gained from investigations of the fundamental physical and chemical processes contributing to device failure may be applied to the prediction and improvement of device reliability. The approach is to construct from such knowledge a computerized mathematical model from which specific prediction and analysis may be numerically obtained. This paper presents some of the results obtained in the program as applied to an evaporated thin film metal alloy resistor. The approach is described. Operative mechanisms affecting resistance are cited. The experimental program is discussed. The present status of the mathematical modeling is indicated.

With respect to the film resistor itself, evidence of oxidation and precipitation have been obtained through the experimental activities on the program. Mathematical models of resistor behavior, relating resistance change to these mechanisms, as functions of temperature and time, have been developed and programmed for computations. The models are currently being updated and validated against resistor reliability data. Techniques for developing probabilistic models have been developed, and they will be applied to the resistor once validation has been completed. (Authors in part)

REVIEW: This paper deals with the same program as the one covered by Abstract and Review Serial Number 1409. The description here is given in less depth, which is more suitable for those not too concerned with the details. The objective of actually being able to predict failure rates for the resistors from a fundamental knowledge of the materials and processes involved in their manufacture is very worthy. A knowledge of specific failure mechanisms could contribute much to reliability improvement. However, it would seem that many problems remain to be solved. ##

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G

Serial Number 1699
ASQC Codes 814;815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Defense industry value engineering techniques

AUTHOR: Arthur F. de la Parra, Loral Electronics Corporation

SOURCE: Transactions 1964 Metropolitan Conference, sponsored by Metropolitan, North Jersey, and Long Island Sections, American Society for Quality Control, New York, New York, June, 1964, pp. 79-82

PURPOSE: To describe the effects of the application of value engineering techniques to government contracts.

ABSTRACT: Value engineering (V. E.) seeks to reduce costs in terms of labor, material, or both. Its value to a contractor depends on the type of contract under which he is operating. Under the Fixed Price type of contract, the contractor will realize the full benefits of a V. E. program. If the changes involve only the amount of labor required to produce the equipment, the V. E. savings is all profit. However, if changes in materials are indicated, the contractor must weigh the cost of obtaining approval for the changes against the potential savings. Under the Cost Plus Fixed Fee contract, the contractor realizes none of the savings resulting from a V. E. study. He does, however, increase his profit ratio, since his costs are reduced while his fee remains the same. With the Fixed Price Incentive type of contract, the contractor is guaranteed a stated ceiling for performing according to its terms. Costs in excess of the ceiling are borne by the contractor. If costs are less than the ceiling, the contractor earns an additional profit based on the cost savings. In these cases V. E. can possibly decrease losses or increase profits. Under the Cost Plus Incentive Fee type of contract, the contractor is reimbursed for all costs, but his profit is determined by his cost overrun or underrun from a stated target. The V. E. savings here will result in an increased profit by an amount equal to the allowable percentages under the contract up to the maximum allowable profit.

The effects of adding V. E. clauses to the above types of contracts are discussed. It is concluded that the addition of a V. E. effort to any type of contract will produce greater profits. Changes which can be applied unilaterally to several contracts are most desirable. Typical V. E. suggestions which have effected savings on various types of government contracts are cited.

REVIEW: This is a clear and concise discussion of the potential results of applying value engineering techniques to government contracts. A central theme of the paper is the improvement of profit. It is important that contractors take a long-range view of the profit motive. Changes which improve profits but degrade the performance/reliability of the equipment are not likely to have long-range beneficial effects and are discouraged by the author. ##

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N65-18424

Serial Number 1700
ASQC Codes 830;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Maintainability--a primer in designing for profit

AUTHOR: Herbert S. Dordick, The RAND Corporation

SOURCE: Transactions 1964 Metropolitan Conference, sponsored by Metropolitan, North Jersey, and Long Island Sections, American Society for Quality Control, New York, New York, June, 1964, pp. 103-111

PURPOSE: To point out that the rapid growth of the service industries will require the learning of new skills in the design and maintenance of equipment, as well as the sharpening of old skills.

ABSTRACT: Maintainability and maintenance are of interest not only to the military and aerospace system designer but also to those engaged in the design of industrial and consumer products. Research in support technology which includes the development of design techniques and operational methods that improve the performance of maintenance, and tools and equipments that extend the art of measurements, will find numerous and useful applications in the non-military and non-space fields. The difficult task of implementing these developments will fall to the designer rather than to the maintainability engineer simply because the economics of consumer and industrial product manufacturing will not allow the added expense of support functions for engineering. In view of the rapid growth of the service industries in this country, there will be a great need for more and better skills in support technology. This need must be satisfied by the design and systems engineers who must improve their skills and strive to become complete engineers rather than specialists.

There is a great need for returning to the fundamentals of measurements not only to improve the checkout of today's complex devices but also to provide new measurement tools for other applications. Many industries including the textile, the prepared foods, and the lumber industries are in need of new and improved measurement devices, many of which are being developed for "checkout" applications. The future prospect for the measurements and instruments business is very bright. (Author in part)

REVIEW: This is a rather broad and general discussion of maintainability and the requirements which it imposes, mainly on the equipment designer. It is contended that much know-how is being developed in the space and military fields which should be very useful in the commercial and industrial world. In many spacecraft systems the designer strives for trouble-free operation over a desired lifetime in a situation in which maintenance is impossible. This could be a worthy objective for the designers of consumer items too, taking due account of such factors as costs and customer satisfaction. ##

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Serial Number 1701
ASQC Codes 822;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Estimation of Weibull distribution shape parameter when no more than two failures occur per lot

AUTHOR: J. L. Jaech, Vallecitos Atomic Laboratory, General Electric Company, Pleasanton, California

SOURCE: Technometrics, vol. 6, pp. 415-422, November, 1964

PURPOSE: To present an estimate of the shape parameter of the Weibull distribution for the situation in which no more than two failures occur per lot.

ABSTRACT: A probability distribution function descriptive of the failure rate in many situations is the Weibull function. Assuming the location parameter is zero, the density function is written:

$$f(x) = (a/b)x^{a-1} \exp(-x^{a}/b), \; x \geq 0; \; a > 0; \; b > 0$$

where a and b are the shape and scale parameters respectively. Of these, a is the more difficult to estimate. Various estimates have been proposed; the "best" one to use depends on the particular situation. Three references to related work are cited. One situation not discussed previously is encountered in reactor fuel element failure studies, where fuel elements are grouped by lots. The elements in a given lot are presumed to be more alike in quality than are those from different lots. Lot designation of manufactured items is, of course, a common practice, not restricted to reactor fuel elements.

This paper presents an estimate, with limits of uncertainty, for the parameter a when failure experience results from the following situation. Lots are removed from service at some target value, normally after experiencing no failures. Some lots experience one failure, and the remaining non-failed items remain in service until the target value is reached. There are a few lots in which two failures occur, and all remaining non-failed items are removed immediately after the second failure. It is assumed that all lots have the same shape parameter; lot differences, when they exist, appear as differences in the scale parameter value.

REVIEW: This is a mathematical paper containing the solution to a special estimation problem involving the Weibull distribution. However, the results are likely to be useful in cases other than the specific one which motivated this work.

Other papers dealing with the Weibull distribution and various aspects of its role in reliability analysis have been covered by Abstracts and Reviews Serial Numbers 320, 437, 499, 749, 751, 801, 848, 1015, 1171, 1435, 1453, 1473, 1538, and 1578. ##

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65A16422

Serial Number 1702
ASQC Code 800

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability

AUTHOR: Paul Alelyunas, Associate Editor (Space/Aeronautics)

SOURCE: Space/Aeronautics, vol. 42, October, 1964, pp. 48-55

PURPOSE: To give a general insight into present approaches to reliability.

ABSTRACT: A lively controversy presently rages between the proponents of the mathematical and physical approaches to reliability. However, it will take a combination of many techniques to ensure the success of space missions. In support of this theme, a sketch of both sides of the picture is presented. The basic statistical approach to the determination of the reliability of a device or equipment is outlined. Maintainability, availability and effectiveness are described briefly. A lack of adequate communication between the statistician and the designer is cited. The physics of failure approach is outlined. Brief reference is made to non-destructive testing techniques, accelerated life testing, personnel-motivating programs, and the increased use of computers. It is concluded that the best hope lies in an "integrated" approach including both the mathematical and the physical to the extent that each can make a realistic contribution to success. Specific references cited are seven reliability textbooks together with a tabular summary indicating their extent of coverage of various reliability subjects.

REVIEW: The author's contention that "a lively controversy presently rages..." seems to be a literary device that overstates the facts. Certainly the two examples given in the text do not prove the point. However, the conclusion that both the mathematical and the physical approaches have something to contribute to ultimate success is reasonable.

This paper covers a lot of ground, and no topic is treated in detail. It should therefore not be relied upon for technical details, but only for impressions. For example, the exponential distribution is referred to as a distribution of failures; in fact it is a distribution of times to failure. Similarly it is incorrectly implied that "randomness" means exponentiality--see Abstract and Review Serial Number 1216 for a discussion of this point. The calculation of reliability for the three-element redundant system is tedious--for the case considered the answer is merely $1 - U^3$, where U is the unreliability. However, if the paper is read for impressions and with a somewhat critical attitude, it has much food for thought. ##

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Serial Number 1703
ASQC Code 775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Non-destructive testing

AUTHORS: R. R. Whymark and W. E. Lawrie

SOURCE: Frontier (published quarterly by IIT Research Institute, 10 West 35 Street, Chicago, Illinois 60616), vol. 25, Spring, 1964, pp. 4-9 (also International Electronics, vol. 8, December, 1964, p. 26)

PURPOSE: To present an expository article on non-destructive testing, indicating the value of various techniques and emphasizing the need for further research and development.

ABSTRACT: As the term is generally applied, non-destructive testing (NDT) involves the introduction of a form of energy into an object, measuring the interaction of that energy with the specimen, and the subsequent interpretation of the results. The energy used could be of almost any type--a magnetic field, light, an electromagnetic field, heat, acoustic waves, etc. As long as the object is partially transparent to the energy and the interactions are known and decipherable, NDT is possible.

With the advancements which have been made in design, the difficulties of successful NDT have increased enormously. Corresponding advances in techniques of NDT have not come sufficiently rapidly. The necessity for NDT must be recognized at the design stage of a complicated system. There is a need for a flexible approach, encouraging investigation of several different techniques and combinations of methods. Large coordinated programs should be instituted to give NDT a rational basis on which to accumulate a storehouse of knowledge free from the restraints and pressure of solving immediate problems. It is important to select technical areas having the broadest generality and satisfying the more urgent of present and future problems for a given dollar investment.

NDT techniques currently under study at IITRI include beta-excited X-ray sources, beta backscatter, capture gamma rays, neutron radiography, ultrasonic image converter, dual-frequency techniques, and fiber optics. In these and other areas, much research and development remains to be done. This will require high-level scientific talent from a variety of technologies.

REVIEW: This is a clearly-written paper which accomplishes its purpose quite well. As such, it is worthy of the thoughtful attention of design engineers and others who might well use these techniques to good advantage. NDT is clearly very important to reliability engineering, and competent studies aimed at solving the more sophisticated problems should prove to be well worth their cost. (See also Abstract and Review Serial Number 1644.) ##

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Serial Number 1704
ASQC Codes 711;720;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Electroplating...key to high reliability contact surfaces

AUTHORS: D. Gardner Foulke and Edwin C. Rinker, Sel-Rex Corporation, Nutley, New Jersey

SOURCE: International Electronics, vol. 8, November, 1964, pp. 19-22, 33

PURPOSE: To describe some plating applications for connectors.

ABSTRACT: In many cases both members of the connector may be made of copper or brass. However, high reliability requirements have led to improved conductivity, low contact resistance and good solderability. Copper and brass often cannot meet these requirements. Further, particular physical properties, such as hardness and low coefficient of friction, have had to be specified. This has led to the widespread practice of electroplating connectors.

Silver is one of the more common plates, but it easily forms sulfides which have poor properties. Gold plate is rather inert and is used where good soldering is essential. Many new gold-plating processes have been recently developed and are briefly described. The platinum metals (mostly palladium and rhodium) are used for special applications and their plating methods are discussed.

In order to provide both profits and proper quality, the processes must be carefully controlled. Some of these controls are indicated in the text. Since the plating industry is changing so rapidly, it is important to use up-to-date figures for comparisons. Yesterday's difficult plates are easy to do today. (Authors in part)

REVIEW: This is a rather general paper--no actual plating processes are discussed in detail, nor are the properties of the plates given except in general terms. There are two tables which list chemical resistance of various plates and some properties of various gold plates. No references, except to patents, are provided. The paper appears to have been written to provide general information for the executive and the engineer, rather than to suggest specific process information for plating engineers and chemists. ##

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61
Serial Number 1705
ASQC Codes 782;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: 26 steps for cooling analysis

AUTHOR: Richard E. Shafer, Lockheed Missiles and Space Company, Van Nuys, California

SOURCE: Electronic Products, vol. 6, March, 1964, pp. 40-41

PURPOSE: To provide a check list on cooling adequacy for use during electrical and mechanical design.

ABSTRACT: Adequate cooling improves reliability, increases accuracy of measurements, and allows increased power dissipation in parts. Suggested steps in solving thermal problems are the following.

1. Reduce dissipated power.
2. Use the ambient as a direct heat sink if possible.
3. Select high-temperature parts.
4. Derate parts as necessary.
5. Estimate the gross heat loads per package.
6. Calculate watts/in^2 of surface through which heat is transferred.
7. For less than 0.25 watt/in^2 use natural cooling.

   For dissipation between 0.25 and 2 watt/in^2 use forced air cooling.

   Above 2 watt/in^2 usually require liquid or vaporization cooling.
8. Estimate the coolant flow and average temperature rises from the graphs.

REVIEW: This is a very brief article which gives some rough methods for calculating average heating and cooling. It can be helpful if used properly. The calculations give conditions necessary, but perhaps not sufficient, for adequate cooling; local temperature differences must eventually be taken into account.

(It should be noted that the ambient is always used as the ultimate heat sink, by definition of ambient; sometimes there are several in-between steps in getting there.)

Other papers dealing with topics related to thermal environmental control have been covered by Abstracts and Reviews Serial Numbers 49, 75, 77, 78, 280, 304, 427, 489, 533, 534, 660, 701, 779, 813, 927, and 962. ##

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Serial Number 1706
ASQC Codes 833;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: How to have equipment failure with high reliability components

AUTHOR: E. E. von Zastrow, Applications Engineer, General Electric Company, Auburn, New York

SOURCE: Electronic Products, vol. 6, April, 1964, pp. 27, 96-99, 101

PURPOSE: To discuss the use of diodes and SCR's as components in reliable circuits.

ABSTRACT: Component reliability can be meaningless unless related to a specified performance and operating environment. The high reliability component may cause unsatisfactory system performance if it is stressed beyond its ratings or capabilities. On the other hand a lower cost general purpose component will perform admirably if it is properly applied and if it is mutually understood between the component supplier and equipment manufacturer what it is designed to do.

Some practical examples are given to illustrate the use of diodes in reliable rectifier circuits. A quantitative comparison is made of the reliability of various circuits. The use of SCR's in static switch applications is discussed briefly.

It is concluded that the desired level of equipment reliability can be attained at minimum cost by selection of the proper component specified to realistic performance and environmental conditions and by the application of good design practice based on an intimate knowledge of component characteristics.

REVIEW: This appears to be a tutorial paper designed for the uninformed technician or perhaps the misinformed engineer. Although it is elementary, and of limited scope, it is clearly written and is not as whimsical as the title suggests. ##

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6

Serial Number 1707
ASQC Code 832

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability

AUTHOR: Margaret A. Maas, Southeastern Editor

SOURCE: Design News, vol. 19, June 24, 1964, p. 8

PURPOSE: To philosophize briefly on human factors in reliability.

ABSTRACT: One survey of nine Air Force missile systems showed that human error caused 20% to 53% of system unreliability; another survey showed that 82% of the defects at a plant were attributable to human error.

Part of the cause of human error is the designer who did not fully appreciate the working conditions and training (or lack of training) of the operator. Much is known now about how to arrange controls and how to "fool-proof" equipment. Designers should use this knowledge.

REVIEW: This is a short essay on "human failures"--the points are worthwhile (but not new). They do need constant repetition. ##

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Serial Number 1708
ASQC Codes 782;835;844

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

TITLE: Infrared looks into integrateds

AUTHOR: --

SOURCE: Electronic Design, vol. 12, May 11, 1964, p. 70

PURPOSE: To describe a method of using infrared cameras to look at the heat distribution in microcircuits.

ABSTRACT: The thermal behavior of microcircuits is something that must be understood for valid reliability and failure analysis. In the study of integrated circuits, work has centered on three basic tools: infrared, X-ray, and electron beam. Infrared has been used the most. With infrared, scanning techniques are used to provide a picture of the heat distribution in the circuit during operation. Brief details of a typical infrared system are described.

REVIEW: This is an interesting news item, rather than a technical article. It is useful for an introduction to this important subject.

Another paper on the use of infrared as an investigating tool in electronics was covered by Abstract and Review Serial Number 626. The use of phosphors in this connection was described in the article covered by Abstract and Review Serial Number 1630. ##

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Serial Number 1709
ASCQ Codes 833;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Improving reliability of micro-inductors

AUTHOR: James A. Foerster, Deluxe Coils Division, Wabash Magnetics, Inc., Huntington, Indiana

SOURCE: Electronic Design, vol. 12, July 6, 1964, pp. 56-57

PURPOSE: To summarize ways of improving the life of coils.

ABSTRACT: Encapsulated-coil reliability actually decreases as the wire size is decreased, rather than remaining the same (or even increasing). The data taken on twisted pairs fails to take into account the many other important factors in an encapsulated coil.

The designer should (1) specify operating conditions, (2) use heavier insulation on finer wires, (3) leave a little extra room for the wire, (4) use other functional aspects of the molded coil, (5) specify wire that has a plastic flow (MIL-W-583), (6) make use of the suppliers' know-how, and (7) use a check-list such as the one in this article.

REVIEW: This is a very short article. The data presented demonstrate the conclusion, but little is given about the background of the data, the type and conditions of test, etc. In any event, the article points up the fact that one should be sure of the changes in reliability before introducing modifications in the components.

The admonition to use a supplier's knowledge is generally worthwhile, although the experience in attempting to do this can sometimes be rather frustrating. ##

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Serial Number 1710
ASQC Codes 720;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Interconnection methods for microcircuits

AUTHORS: J. W. Slemmons and J. R. Howell, Materials and Processes Lab., Autonetics, Division of North American Aviation, Inc., Anaheim, California

SOURCE: Electronic Design, vol. 12, September 14, 1964, pp. 78-83
but see 66A32115

PURPOSE: To survey the methods of making contacts to and between micro-electronic elements.

ABSTRACT: The ideal technique for making microcircuit interconnections should be rapid and economical and at the same time yield joints that can be inspected easily and repaired without further damage. Eliminating the variability associated with human operators is highly desirable.

No one, clearly superior, universally applicable method exists. Nine techniques which have been successful in certain applications or appear promising are: (1) resistance soldering, (2) cross-wire welding, (3) resistance welding, (4) electron beam welding, (5) laser welding, (6) wedge bonding, (7) nailhead bonding, (8) ultrasonic bonding, and (9) series (micro-gap) bonding. The operational principles of each of these techniques are briefly outlined and the relative advantages and suitability for typical microcircuit operations are contrasted.

REVIEW: The topic of this paper is more fully described as methods of making (1) intraconnections among various elements on a silicon chip; (2) connections between areas on the chip and the leads of its package; and (3) interconnections between the package leads and printed circuit boards or other mounting fixtures. Each of the nine techniques is described qualitatively in several short paragraphs.

A series of photomicrographs illustrating both the appearance and cross-section of the joints formed by the various techniques is worthy of special mention. On the other hand Figure 3, showing the effect of aging time and temperature on the solderability of different materials, defies interpretation within the limits of the information presented with the figure or in the accompanying text.

The survey of interconnecting methods seems fairly complete, although the use of evaporated or deposited leads seems to warrant some consideration within the broad spectrum of techniques considered here. ##

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Serial Number 1711
ASQC Code 833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Choosing relays or solid-state switching

AUTHOR: John A. Pfingsten, Hi-G Incorporated, Windsor Locks, Connecticut

SOURCE: Electronic Industries, vol. 23, June, 1964, pp. 99, 101, 103

PURPOSE: To discuss the relative merits of the electromechanical relay and the solid-state switch.

ABSTRACT: Solid-state switches are finding uses which cannot normally be filled by standard electromechanical relays; these two devices are not necessarily interchangeable, and neither has a complete advantage over the other. The choice of device depends on the use.

The various parameters which must be considered in design application of a switching device are discussed. A table is given as a quick reference guide to those parameters which are best handled by either the relay or the solid-state switch.

REVIEW: This is a straightforward unsophisticated discussion of the relative properties of relays and solid-state switches. The author has been quite impartial and does not maintain that either device is the answer to all switching problems. ##

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G

Serial Number 1712
ASQC Codes 711;770

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Short-time relaxation test for spring materials

AUTHOR: C. L. Carlson, Central Research Laboratories, Westinghouse Electric Corporation

SOURCE: Materials in Design Engineering, vol. 59, June, 1964, pp. 110-111

PURPOSE: To describe a 168-hour relaxation test for spring materials that will help select materials for long life and accurately predict long-time load and permanent set.

ABSTRACT: A relaxation test has been developed to enable the quick determination of long-time behavior of coiled springs after a 168-hour test period under service load. Approximately half of the load loss and half of the permanent set that would be developed under service load will occur in that time. Although the test has been used principally for power or acceleration breaker springs, it can be used to test any type of coiled spring (or material wound into a coiled spring) for room temperature performance.

REVIEW: Although the author is mainly concerned with large-size springs, this article should also be of interest to relay designers in that the test used could be adapted to small flat springs. The test appears to be quite useful.

Another paper concerned with the properties of spring materials was covered by Abstract and Review Serial Number 1564. ##

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Serial Number 1713
ASQC Codes 833;873

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: MoS_2 solid lubricant extends ball bearing lifetime

AUTHOR: (Editorial Matter)

SOURCE: Bell Laboratories Record, vol. 42, pp. 296-297, September, 1964 (also The Iron Age, vol. 194, August 6, 1964, p. 66)

PURPOSE: To show that MoS_2 lubricant is useful for ball bearings.

ABSTRACT: The use of MoS_2 for ball bearings has been specifically not recommended since it was feared that the solid particles would agglomerate and clog the bearings. Tests have shown that this is not the case if the bearings are run without the shields. The lubricant was a grease of MoS_2 powder and mineral oil, with a lithium hydroxy stearate soap; the MoS_2 is more than 50% of the grease. The wear life is up to ten times as long as the average for bearings with conventional lubrication. In unattended offices, the conventional life is about one year.

The reason for the long life is that with the shields removed, an escape route is provided for the excess agglomerate paste which is squeezed out. It serves as a reservoir, replenishing the bearings with lubricant. Clearances fill up, and an "equilibrium" with extruded particles is maintained. The excess also forms an outer crust which hardens and shields the bearings from foreign matter.

Inside the bearing unit, presumably the mineral oil base in the lubricant polymerizes at the test temperatures. Contact with oxygen also forms weak organic acids which etch the balls and races lightly. The MoS_2 powder packs into these tiny etchings smoothing them out; it lubricates the metal surfaces with the aid of the polymerized oil which acts as a resin binder. The total effect is a bonded solid lubricant film which is constantly replenished. (Author in part)

REVIEW: This is an interesting topic and is briefly but well presented. The paper also serves to show the route by which progress is sometimes made. ##

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1/65 65A 28660

Serial Number 1714
ASQC Codes 711;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Fused silica as an aerospace material

AUTHORS: R. L. Hallse and J. H. Rizley, General Dynamics, Pomona, California

SOURCE: 10 pp., presented at the Sixty-seventh Annual Meeting of the American Society for Testing and Materials (1916 Race Street, Philadelphia 3, Pennsylvania), June, 1964 65A-28658

PURPOSE: To review the mechanical, physical, and electrical properties of fused silica and compare them with those of other ceramics.

ABSTRACT: The mechanical, physical, and electrical properties of fused silica are reviewed and compared with those of other ceramics. Particular attention is directed toward the thermal shock resistance of fused silica as compared to alumina, Pyroceram 9606, and beryllia. Techniques for fabricating specific shapes out of fused silica are discussed and the advantages of slip casting are pointed out. The strength of slip cast fused silica is analyzed in light of typical missile and aerospace requirements. It appears that for most radome applications the strength of slip cast fused silica is adequate. A successful method of attachment, always a problem with low expansion ceramics, is presented.

The factors affecting the transmission of electromagnetic radiation through dielectrics at microwave frequencies are discussed and the relative advantages and disadvantages of fused silica radomes are pointed out. Data are presented that show fused silica to have exceptional electrical properties for radome applications.

The results of recent rain-erosion tests on slip cast fused silica are presented. Such variables as surface condition, specimen geometry, and attachment are discussed. It appears that, by the use of proper design, rain erosion need not be a problem with fused silica. An explanation of the somewhat unusual rain erosion characteristics of slip cast fused silica is included.

Applications are cited in which the outstanding thermal shock resistance, stable electrical properties, and exceptional dimensional stability of fused silica are being utilized in aerospace applications. (Authors)

REVIEW: This is a workmanlike paper which contains interesting and useful information on the properties of fused silica and other ceramics. It will be of interest to those concerned with the selection of materials for missile and aerospace applications. Much of the paper is devoted to the discussion of the use of fused silica in radomes. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Modern electronics packaging

AUTHOR: Alexander A. McKenzie, Associate Editor

SOURCE: Electronics, vol. 37, February 7, 1964, pp. 33-48

PURPOSE: To give a survey of modern electronic packaging techniques.

ABSTRACT: Packaging has been defined as the process of physically locating, connecting and protecting devices or components. Packaging information presented in this report was compiled from a comparable viewpoint. The subject is discussed under the headings of:

Interconnection
Environment
Cooling
Encapsulation
Microcircuits

A bibliography of 89 papers is appended.

REVIEW: This survey paper is interesting and easy-to-read. It would be worth having at hand for the bibliography alone. The author, in a private communication, has pointed out that in this field things move fast and time may have dulled some of the value of this report. For those who are interested, some copies of the reprint are still available (from McGraw-Hill Publishing Company, Inc., 330 West 42nd Street, New York 36, New York). ##

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Serial Number 1716
ASQC Code 800

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability starts with teamwork

AUTHOR: C. O. Bancroft, TRW Valve Division, Thompson Ramo Wooldridge, Inc.

SOURCE: SAE Journal, vol. 72, November, 1964, p. 68

PURPOSE: To give a brief summary of duties of each group which helps to produce a reliable product.

ABSTRACT: In today's competitive market, reliability and quality must be improved without increasing costs. With extended automotive warranties, good reliability means low service costs during the warranty period. Three groups--design, manufacturing, and quality control--are responsible in their own areas for reliability. Each group must know the capabilities and limitations of the others and of the materials and processes for making the product. Each group must trust the others to perform properly. Finally, the groups must communicate adequately with each other.

REVIEW: As a general essay on high reliability/quality this is a good short article. The emphasis on design engineering's really understanding the limitations of materials and manufacturing processes is very good. The article appears to be a summary of a longer treatment and is aimed toward beginners in the field. ##

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Serial Number 1717
ASQC Code 833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Relay facts--Three big questions

AUTHOR: E. U. Thomas, Staff Columnist, Grumman Aircraft Engineering Corporation

SOURCE: Electromechanical Design, vol. 8, October, 1964, pp. 18-20

PURPOSE: To raise questions about dielectric tests, rupture capacity, and relays vs. solid state.

ABSTRACT: Dielectric tests are essential for aircraft equipment and wiring but there is little agreement on the details. There are inconsistencies in practices for parts that end up in the same place. There is the question of ac vs. dc. Some small relays are only rated at 200 to 500 volts whereas coil voltages on break can reach several thousand volts if the transient is not suppressed.

Fault currents may reach many times the steady state current and protective devices must be able to rupture these large fault currents. Efforts to save space, time and money should not overlook the necessity for a circuit's being able to safely fail without destroying itself or other equipment. Poorly designed equipment from this point of view may be very costly.

Relays, where properly applied, are, have been, and will continue to be very reliable. Solid state devices are not always better than relays no matter what criteria apply. Relays can be both cheaper and better, but they must be made right, specified right, and applied right.

REVIEW: The three points are well made and well illustrated. The problem of relays vs. solid state (meaning semiconductors obviously, since relays are also "solid-state") is worthy of special mention because so many designers seem to have lost sight of the good reasons for using relays in some applications.

This is a regular column and is worthy of the attention of all who are interested in reliability as it pertains to relays. Few, if any, columns deal with reliability per se, but many deal with it indirectly through proper application and specifications. ##

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Serial Number 1718
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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Switch application checklist

AUTHOR: Art Siegel, Staff Columnist, Radio Corporation of America

SOURCE: Electromechanical Design, vol. 8, October, 1964, pp. 22-23

PURPOSE: To point out the need for proper application of switches.

ABSTRACT: Many switch failures are due to misapplication. Since many needs change so rapidly, a checklist is soon out of date. Each designer must be sure that the switch he chooses can withstand the environment safely. With space applications requiring greater vibration and vacuum resistance the designer is having a harder time. Every requirement or characteristic of a switch must be investigated. One overlooked parameter may mean a failure of the equipment. Remember--a properly applied switch is reliable; when improperly or arbitrarily chosen it is a hazard! (Author in part)

REVIEW: While the title is somewhat misleading since there is no checklist, the column is worth reading. Reliability is best served by attention to detail such as insisted upon here.

This is a regular feature and while reliability per se is not often mentioned, the column regularly deals with design, applications, and specification, all of which are vitally important for high-reliability applications.

The author, in a private communication, has indicated that the intent of the title of his October column was to make engineers aware of the fact that they must make a checklist before deciding upon a switch to use for a specific application. ##

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Serial Number 1719
ASQC Codes 815;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Specifications for high reliability rectifiers

AUTHOR: Harvey Kaufman, Rectifier Component Department, General Electric Company

SOURCE: Electronic Evaluation & Procurement, vol. 4, September, 1964, pp. 42-45

PURPOSE: To show that a proliferation of user's reliability specifications may lead to unreliability.

ABSTRACT: Minuteman is the example of a successful program to make high-reliability parts readily available. The success is in large part attributable to the responsible central control and continuous volume usage of the parts. MIL-S-19500/D, recently released, incorporates some of the "Darnell recommendations" but has seen little use so far. Experience with it will probably produce modifications. Supplier specifications such as GE's R700 series are a step in the right direction and will eventually be superseded by military specifications. The most recent effort is MIL-S-38103, but so far there has not been enough feedback to refine it.

User specifications are the poorest of all because a manufacturer makes so few of any one kind of device that reliability data on them are completely inadequate. Parts may actually be less reliable than if purchased to a more widely used, less restrictive specification. Effort should be on upgrading MIL-S-19500 to satisfy aerospace reliability requirements.

REVIEW: The problems the author discusses are real and severe; the solutions are difficult. The design engineer has his problems too (they are not discussed in this article). In the long run they are best solved by the approaches outlined here; unfortunately they must also be solved in the short run. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Design practices to minimize sleeve-bearing fatigue

AUTHOR: Richard F. Jacobs, Design Engineer, Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., Warren, Michigan

SOURCE: Machine Design, vol. 35, December 19, 1963, pp. 134-139

PURPOSE: To give design criteria for reducing the tendency to fatigue.

ABSTRACT: Sleeve bearings can fatigue even with relatively light loads if the load cycling occurs often enough. To improve matters the following points should be considered.

1. The higher the shaft speed, the lower the L/D ratio.
2. Grease lubrication requires high L/D ratios.
3. The backing material and housing should be stiff enough to prevent excessive deflection under load. Bronze backing must be at least three times as thick as steel backing.
4. Most bearing materials can have adequate fatigue life if they are 5 to 15 mils thick.
5. Greased bearings should have provision for flushing out the dirt, or seals for keeping it out, or both. Proper grooves are desirable in the bearing.
6. Oiled bearings are designed differently for the several methods of oil feed. It is important to remember that hydrodynamic lubrication involves a very thin oil film. This film must be kept cool and thus constantly replaced in many applications.
7. Bearings which stand idle may lose an oil film and be damaged during start-up.
8. Misalignment is bad, of course, and tends to be worse for large L/D ratios. Shaft deflection under load should be considered.
9. Good surface finishes are important on the inside of the housing since they promote good heat flow and are not easily burnished during operation (burnishing increases the bore size). Naturally the bearing surfaces themselves should be very good.
10. The shafts should be round and true and have good finish. Bearings tend to fatigue especially when debris gets inside. This causes excessive heating which reduces the fatigue strength. Particles eventually spall off and become more debris themselves.

REVIEW: This is a good summary of mechanical design factors for metallic sleeve bearings. It is not intended to cover choice of material. No reference is made to plastic bearings which have advantages over metal ones in many applications. There is a minor error where high-strength steel alloys are alleged to be stiffer than low-carbon steel. In truth, virtually all steels have about the same Young's Modulus (stiffness); it is the elastic limit or yield point that varies from steel to steel. ##

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65A10421

Serial Number 1721
ASQC Code 775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Finding malfunctions before they happen

AUTHOR: Robert C. McMaster, The Ohio State University, Columbus, Ohio

SOURCE: Electronics, vol. 37, November 16, 1964, pp. 75-81

PURPOSE: To describe some of the newer techniques in nondestructive testing.

ABSTRACT: Four significant advances in nondestructive testing are:

1. Electronic magnification of X-ray "pictures" so that the resulting image is easily and safely examined. Articles in motion can be examined. Resolution is exceedingly good.

2. Neutron radiography casts shadows due to differences in atomic number. The low atomic numbers--especially hydrogen--scatter thermal neutrons very well. Many difficulties are yet to be solved, however.

3. It is now possible to convert the results of ultrasonic testing to a television type of display. The resolution here can be as good as that of X rays.

4. Microwave reflection and absorption measurements can measure the thickness of coatings. There is still much work to be done in developing microwave measurements as a tool for nondestructive testing.

REVIEW: This is a brief look at several methods which make nondestructive testing more convenient and more effective for detecting flaws. Other than some editorial difficulties (physicists will be surprised to learn of neutrons that are focused), the article serves its purpose well. There are no references. For other articles on nondestructive testing methods see Abstracts and Reviews Serial Numbers 1644 and 1703. ##

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65N83293

Serial Number 1722
ASQC Code 800

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability in guided missile systems

AUTHOR: Richard R. Carhart

SOURCE: P -315, 15 pp., The Rand Corporation, Santa Monica, California, 7 July 1952 (DDC AD No. 422820)

PURPOSE: To discuss the technical problem of reliability in guided missiles.

ABSTRACT: Guided missiles involve the use of a multiplicity of electrical, mechanical, and electro-mechanical devices under very severe conditions. All of these components must operate during the time the missile is in the air. In addition, before and during the flight phase an organization of men and machines must also perform properly on the ground, on shipboard or in aircraft. And finally, a complex man-machine support system must function properly in development, production, supply, testing, and maintenance, to insure the desired operation of the guided missile system.

The reliability of a missile system can be improved in four fundamental ways: by improved components, by improved design, by improved selection and training of personnel and standard operating procedures, and by component redundancy.

Reliability of the hardware in a missile system is fundamentally the result of engineering which takes into account realistically and from a systems point of view all the significant factors affecting the performance of the weapon. Reliability is a difficult and important technical problem which requires careful planning, a large effort, and great attention to details. Reliability and the associated problem of accuracy are the primary factors governing the time at which guided missile systems will become operational. Without adequate attention to reliability, both on the part of the using Services and the contractors, these operational dates will be delayed. (Author in part)

REVIEW: Somehow this document had a delayed entry into the DDC system (although the report is over 12 years old, it has a quite recent accession number). However, the subject and comments are as pertinent now as they were when written. Reading it helps one to put in perspective much of what is published now. ##

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Serial Number 1723
ASQC Codes 711;782;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: New aerospace fluids and lubricants

AUTHOR: Robert J. Fabian, Associate Editor, Materials in Design Engineering

SOURCE: Materials in Design Engineering, vol. 58, August, 1963, pp. 77-80

PURPOSE: To present a report on conventional and liquid metal lubricants, high-temperature greases, hydraulic fluids, and coolants.

ABSTRACT: During the USAF Aerospace Fluids and Lubricants Conference at San Antonio in April 1963, state-of-the-art reports were given. This is a summary of some of those reports.

Better lubricants are needed now for Mach 2.5-3.5 turbojet and turbofan engines. Bulk oil temperatures are approaching 400°F and can be expected to rise to 600°F. Above Mach 3.5 bulk oil temperatures from 500-700°F are expected. Few if any lubricants can come even close to meeting these requirements for sufficiently long missions.

Liquid metal working fluids which double as lubricants may simplify designs and lower the weight of aerospace systems. There are difficulties however, such as: (1) high density means larger fluid inertia effects, (2) the problems of cavitation are intensified, (3) low damping may cause trouble in low gravity, (4) poor boundary layer properties, and (5) excessive corrosion.

Promising high-temperature greases are available. Some organic lubricants have been made into greases which perform well at 600°F. Inorganic greases have excellent heat stability but particle size and surface properties deter good normal performance. Boron nitride as a grease thickener is an example.

Fluid coolants are satisfactory up to 400°F. For higher temperatures compromises must be made in the low-temperature properties (below -40°F). More realistic and exact figures of merit are needed.

Hydraulic fluids still have high-temperature problems. They must have improved fire resistance, long-term stability and resistance to radiation. Deep-dewaxed mineral oils show promise as a base fluid over the range -75 to 700°F. Other fluids under development and analysis may go as high as 1000°F, but all have some present drawbacks.

REVIEW: This is a good article for those who must have a broad knowledge of the field. Many of the products are named and information is given about them. Reliability of aero-space vehicles depends greatly on developments and proper applications in this field. ##

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Serial Number 1724
ASQC Codes 711;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Flaws no key to casting failures

AUTHORS: Staff, Materials in Design Engineering

SOURCE: Materials in Design Engineering, vol. 58, November, 1963, pp. 88-89

PURPOSE: To show that flaws do not cause casting failures.

ABSTRACT: Service failures in castings have often been attributed to a decrease in casting yield strength or ductility caused by the presence of casting discontinuities. Many times the true culprit is inadequate design which results in damaging stress concentrations. While it is extremely difficult to persuade users of castings that this is actually the case, studies by the Steel Foundry Research Foundation have shown that over 95% of all service failures are directly attributable to stress concentrations resulting from improper design.

The complete study of the relationship of discontinuities to casting failure used 12 different steel castings. Two of them are discussed in this article. One of the castings, although subjected to stresses many times greater than anticipated service stresses, could not be made to fracture; it failed by substantial plastic deformation. (Authors)

REVIEW: Undoubtedly there is much to be said for the point of view of this paper. Many flaws in castings appear in places where there is overdesign anyway. The items were apparently all tested in ultimate strength where considerable plastic deformation can occur before failure; this will mitigate the effect of flaws. Fatigue failure, which tends to be brittle in nature, would be expected to be much more influenced by flaws. The tests were all on steel castings and the results are probably not directly carried over to less ductile materials.

The contention that many unexpected failures are due to poor design is probably true here as it is in most anything from bulldozers to electronic equipment. ##

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Serial Number 1725
ASQC Codes 711;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Materials Selector Issue

AUTHORS: Editors, Materials in Design Engineering

SOURCE: Materials in Design Engineering, vol. 60, Mid-October, 1964, entire issue (614 pp. including advertising)

PURPOSE: To summarize property data on many kinds of materials.

ABSTRACT: An initial section entitled "Comparisons of Materials" lists physical, corrosion, and electrical properties and costs of materials on comparative sheets. The remaining sections are composed of property data pages on the standard materials in the following categories:

Irons and steels
Nonferrous metals
Plastics and rubber
Ceramics, glass, carbon, mica
Tubes, felts, wood, and paper
Finishes and coatings
Composite materials
Forms and shapes of materials
Joining and fastening

REVIEW: Reliability is profoundly influenced by the designer's choice of materials. Many decisions are made at an early stage on the basis of general information. Compendia such as this are a valuable source of information to designers, reliability engineers, value engineers, and others who cannot possibly hope to remember even a small fraction of the information. The material does not bear on the subject of reliability per se, but many design faults could have been avoided had the designer used a handy reference on properties of materials. This particular one is quite comprehensive. ##

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64 X15717

Serial Number 1726 -1
ASQC Codes 824;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Semiconductor reliability

AUTHORS: George J. Blakemore, Edward T. Kronson, and William H. von Alven, ARINC Research Corporation, a subsidiary of Aeronautical Radio, Inc., 1700 K Street, N. W., Washington 6, D. C.

SOURCE: Publication No. 239-01-4-383, ~~301~~ 419 pp., 31 July 1963, Final Report prepared for Department of the Navy, Bureau of Ships under Contract NObsr-87664 by ARINC Research Corporation, Washington 6, D. C. (DDC AD No. ~~416492)~~ 437692

PURPOSE: To present the results of a research program for the determination of quality assurance requirements for specific semiconductor devices and the determination of confidence limits for the shape parameter of the Weibull distribution.

ABSTRACT: In this final report, ARINC Research Corporation presents the results of a research program authorized by the Bureau of Ships. The main objectives of the program were to determine quality assurance requirements for specific semiconductor devices, and to determine confidence limits for the shape parameter β of the Weibull distribution. A summary of the main findings is given below.

Of particular interest is the fact that integral circuits used in digital applications are potentially as reliable as a single discrete transistor used in digital applications. Another finding of significance is that the distribution of field removal rates for diodes in regulator and rectifier applications is approximately the same as the distribution of field removal rates for transistors used in amplifier or high-power applications. On the average, the removal rates for devices in analog (amplifier) applications are approximately 300 times higher than the rates for devices in digital applications.

Eight manufacturers supplied life test data on 24 popular types (20 families) of semiconductor devices. In almost every case where the presence of failure permitted an estimate of the Weibull parameters, the resulting hazard functions were decreasing over time. This decrease indicated that the majority of failures occur early in the life of these devices and result primarily from manufacturing defects or careless handling. The existence of any "wear-out" mechanism in the devices was undetected.

Confidence limits for the Weibull shape parameter β show that because relatively small sample sizes are typically used in the life testing of semiconductor devices (< 100 items) the confidence intervals are so broad as to preclude the use of Weibull sampling plans. The continued use of the Sobel-Tischendorf plan

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that is incorporated in MIL-S-19500 is therefore recommended during production. (Authors in part)

REVIEW: This report compiles reliability and life test data from numerous sources, and does a useful job of analyzing them. Field removal rates for several semiconductor family types are presented in a convenient form for making comparisons, and enough information is included (e.g., type of equipment or systems monitored, component applications) to make the comparisons significant. Life test data on 24 types of transistors are presented in reasonably complete detail. The test conditions and sample sizes are specified, and the parameters monitored (usually h_{FE} and I_{CBO}) are indicative of degradation that may occur in the transistors. The life test data also came from numerous sources and, generally, the test conditions were different. Consequently, direct comparisons of the transistors included are limited to only a few.

In determining the estimate of the Weibull shape parameter, the authors seem to arbitrarily define failure for the transistors, and these criteria are not included in the report. A definition of failure would probably be of interest to many readers. A subsequent determination of confidence limits for the Weibull parameters was based upon reasonable assumptions that are justified in the report, and the procedures followed are well presented.
##

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Serial Number 1727 -1
ASQC Codes 782;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Heat transfer design for electronic equipment (in three parts)

AUTHOR: Leonhard Katz, Astro Dynamics, Inc., Northwest Industrial Park, Second Avenue, Burlington, Massachusetts

SOURCE: Electromechanical Design, vol. 7, October, 1963, pp. 32-38 (Part I), November, 1963, pp. 28-32 (Part II), and December, 1963, pp. 36-40, 42 (Part III)

PURPOSE: To present a simplified version of the theory of heat transfer and to provide as many simple charts, nomographs, and time-saving devices as possible.

ABSTRACT: One of the first things to note is that heat transfer units tend to be different from electronic units. There is no conceptual difficulty involved; one needs only to be careful.

Natural convection is the usual method of heat transfer. There is a boundary layer next to the surface which tends to impede the heat transfer. A heat transfer coefficient (Btu/hr-ft^2-^{o}F) is introduced to account for the impedance of this layer. (A formula is given which is reasonably good for these calculations.) Several terms such as Nusselt, Grashof, and Prandtl numbers are introduced and explained; their use simplifies the calculations. (Three examples are given to illustrate the calculations.) Radiation rarely helps very much to get rid of heat under these circumstances. Fins are much better, but they should not be too close together. A rule of thumb suggests 1/2" as the minimum distance.

Calculations for forced convection use the same types of "numbers" as natural convection. The Reynolds number (Re) is introduced and gives an idea whether the flow will be laminar (smooth or streamline) or turbulent. The transition occurs around Re = 2300. Turbulent flow results in a thinner boundary layer and better heat transfer, but has a greater pressure drop. One must be sure that most all of the air goes close by the hot components where it does some good. High air velocity tends to be helpful but increases the pressure drop. (Three examples are given.)

The following seven rules or steps are given to aid the designer.

1. Determine the heat density and the maximum temperature rise allowed for the components.
2. Below 300 watts/ft^3 use natural convection; above 1000 watts/ft^3 use liquid cooling; between the two use forced air convection--all for "ordinary conditions".
3. Fans and blowers should consume no more power than 10%

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

of the heat to be dissipated.

4. Determine the minimum amount of air needed to cool the equipment.

5. If required, determine the pressure drop and select a cooling fan or blower.

6. "Design" a heat exchanger for each component. Many times this will simply be the case.

7. Always complete the heat flow diagram from beginning to end. Do not just assume that the heat will get away somewhwere unless there actually is a way for it to escape. Be careful that the intakes do not suck in warm air from the exhaust of its own or other equipment.

The calculations for liquid cooling follow the same principles, but need more graphs and charts because of the several possible liquids and the great change in properties with temperature. (Three examples are given along with graphs for about six coolants.) Water is one of the best liquids if its limitations can be allowed.

For outer space cooling one must use radiation, thermal inertia or ablation. Radiation calculations are straightforward except that the emissivity in the visible is not the same as in the infrared. Always be sure to look up the emissivity. For example, white enamels have a higher emissivity in the infrared than does black lacquer. Thermal inertia--just the rise in temperature of the equipment and its surroundings--can be used for short-time cooling. Ablation can be used for somewhat longer periods; the evaporation of water is an excellent method. (One example is given.)

REVIEW: This series will require some study, but it will be well worth the time required. The discussion is kept simple, yet no real violence is done to any important concepts. One usually throws in some safety factor anyway. The curves and graphs should be of help. (The projected fourth part of the series--Design Applications --was not published.) Any electronics/electrical engineer can easily follow the material and no extensive external references are required.

The author, in a private communication, has indicated that a somewhat expanded version of this series under a single cover is available for $2.00 from Astro Dynamics, Inc.

A listing of Abstracts and Reviews of other papers dealing with topics related to thermal environmental control is given in Review Serial Number 1705. ##

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Serial Number 1728
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: New facts in integrated circuit reliability

AUTHOR: (Editorial Matter)

SOURCE: Electronic Equipment Engineering, vol. 11, September, 1963, pp. 16-19

PURPOSE: To summarize some information on the reliability of integrated circuits.

ABSTRACT: This article summarizes the results of integrated circuit test programs reported by four manufacturers. In general the type of test program is given, the number of samples and the results are statedin raw form. Some life data are tabulated below.

1. One failure occurred in 2409 networks operating in customer applications for 3.8×10^6 network hours.
2. In 31 weeks of weekly samples, 153 units completed 1000 hours at 125°C without failures.
3. A fourth quarter 1962 failure rate, extrapolated to 85°C, is 0.54%/1000 hours.
4. In a circulating ring oscillator circuit at 125°C, the following results were obtained:
   (a) 20×10^6 network test hours with 5 failures
   (b) 4×10^6 network test hours without failures
   (c) 11×10^6 network test hours with one failure.
5. A 25°C failure rate of 0.01%/1000 hours for linear units and 0.06%/1000 hours for logic blocks.

REVIEW: This summary article is worthwhile reading for the busy engineer interested in the reliability of integrated circuits. It is factual and to the point. The final paragraph predicts that the MTBF's of microcircuits will asymptotically approach those of transistors. This statement can now be considered fact and not prediction. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The science of component reliability

AUTHOR: Morton E. Goldberg

SOURCE: Frontier (published quarterly by IIT Research Institute, 10 West 35 Street, Chicago, Illinois 60616), vol. 24, Spring, 1963, pp. 10-13

PURPOSE: To show a new approach to the prediction of the reliability of electronic components.

ABSTRACT: This is the reliability dilemma. System complexity, operating times, and environmental stresses are all increasing, whereas the consequences of system failure are becoming more intolerable. The mass test approach for parts is rapidly becoming prohibitively expensive and time consuming. Yet the need for established reliability figures has never been greater.

The new Physics of Failure program takes the point of view that every failure has at least conceptually an assignable physical cause. It attempts to emphasize the physical processes which are at work and to apply the required statistical treatment at a much lower level of detail.

The ultimate hope of such an approach is that mathematical models for computer programming be developed for related types of components. Upon the generation of proper data, component behavior under any circumstance could be closely predicted.

Essentially, the behavior of all pertinent parameters of any component must be known over the total possible range of environments and operating conditions; then life characteristics can be predicted. (Author in part)

REVIEW: This is an optimistic and general summary of the benefits of the Physics of Failure program. Not that the program is not necessary, but its fruition is likely to be less encompassing and further off in time than is implied here. As examples of current efforts see Abstracts and Reviews Serial Numbers 1406 through 1416, 1456 through 1465, and 1506 through 1517. ##

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Serial Number 1730 -1
ASQC Codes 711;712;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Preventing fatigue failures

AUTHORS: F. B. Stulen, H. N. Cummings, and W. C. Schulte, Propeller Division, Curtiss-Wright Corporation, Caldwell, New Jersey

SOURCE: 34 pp., reprinted from Machine Design, April 27, May 11, May 25, June 8, June 22, and July 6, 1961, price $1.00, The Penton Publishing Company, Cleveland 13, Ohio

PURPOSE: To discuss frequently overlooked factors that affect fatigue strength and to outline methods which are helpful in designing against fatigue failure.

ABSTRACT: While much is known about fatigue both on a macroscopic and a microscopic scale, it is generally conceded to be fundamentally not understood. This series of articles deals with fatigue on an engineering basis. The topics included are: Basic Factors, Geometric Stress Concentrations, Heat Treatment and Surface Hardening, Surface Treatment and Environment, Calculating Fatigue Strength, and Biaxial Fatigue Stresses. Most fatigue failures can be traced to design rather than to material deficiencies. If the loads fluctuate, fatigue occurs, and the material can fail at stresses well below the ultimate strength. A histogram showing the magnitudes of the fluctuating loads is helpful. Many design features affect the fatigue life. Fatigue failures tend to be "brittle failures" and so ductility is not able to play as large a part as it does in ultimate strength failure. Corrosion and notches are especially bad.

Stress concentrations can be calculated from the theory of elasticity and can be measured by photoelastic or other strain-measuring methods. The fatigue strength is not always reduced by this factor however--for reasons usually attributed to local yielding, but not fully understood. Many techniques are available for reducing stress concentrations such as large radii in size transitions and the elimination of fabrication defects on the surface.

Since many fatigue failures tend to begin at the surface (partly because most bending stresses are highest at a surface), proper treatment of the surface can improve the fatigue strength. Compressive stresses for some reason are usually beneficial; these are put in by nitriding and carburizing. The fatigue strength of an alloy is not directly proportional to its tensile strength, although hardening usually improves the fatigue strength. (Hard materials tend to be brittle and may fail in modes other than fatigue.)

The surface can also be peened, hammered, or rolled to improve fatigue properties. The mechanism of improvement is not known

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exactly, but again, compressive stresses at the surface are presumed to play a part. Plating or clothing ("cladding") a surface may either help or hinder the fatigue life. Nickel and chromium plating are detrimental. Where corrosion is a problem, the plating may be a net help anyway. Sometimes shot peening before plating can overcome the bad effects of plating. Fretting, the small relative movement of two pieces in contact, lowers the fatigue strength considerably.

A few methods are given for estimating the fatigue behavior of parts. They are not very exact, but there are so many uncertainties in the processes anyway, that exact methods would be of no help.

REVIEW: This is a good engineering discussion of fatigue. The beginner will find it informative and very helpful, but it contains no cookbook solutions to his problems. This is probably because fatigue problems are rarely solved by beginners. There are many references for further reading. All-in-all, everyone who has fatigue problems will find this collection at least interesting and probably informative.

(One cliché repeated here that deserves more explanation is that a fatigue failure is usually due to design, not to the material. Obviously, it is the material that fails--always. Thus what is really meant is that most portions of the equipment or part were considerably understressed and that these high stresses occurred only in a very few places. This can be corrected by a moderate redesign and the new design is then considered to be adequate.)
##

Serial Number 1731
ASQC Codes 782;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Basic analysis of liquid cooling systems

AUTHOR: John J. Mandish, Advanced Development Group, Philco Corporation, Willow Grove, Pennsylvania

SOURCE: Electronic Design, vol. 11, August 16, 1963, pp. 74-78, 80, 81

PURPOSE: To review thermal analysis equations bearing on indirect liquid cooling of electronic equipment.

ABSTRACT: There are three major quantities to be computed in the thermal analysis:

Heat balance for the hot fluid,
Heat balance for the cold fluid, and
Heat exchange between fluids.

These three quantities figure in the two locations where heat exchanges take place. The first two computations employ the usual conductive heat flow equation. The third quantity is more of a problem for the designer. The computation of this quantity is quite important, for it leads to the specifications for the external heat exchanger.

Obtaining a correctly sized, small and efficient heat exchanger is one of the main goals in a cooling system design. For electronic applications, compact finned-tube types are attractive, particularly when the coolant inside the tubes is either a high-pressure gas or a liquid and the fluid outside the tubes is air at ordinary pressures. Heat transfer coefficients, actual effective areas, etc., must all be considered (and are explained in the text). (Author in part)

REVIEW: Most electronics designers after reading this paper are apt to feel that the best way out is to specify performance of the heat exchanger and let someone else worry about the details. While there is much to be said for that point of view, some familiarity with heat exchanger calculations is a good idea and this article can help in that respect.

In a private communication the author has stated that the original intent of the article was to give the electronic design engineer enough theoretical and practical heat exchanger background to allow a basis of good design between vendor and user for any application.

Those concerned with heat transfer design for electronic equipment should see also the paper covered by Abstract and Review Serial Number 1727. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: System reliability over an operational spectrum

AUTHOR: Howard L. Leve, Structural Mechanics Section, Missile and Space Systems Engineering, Douglas Aircraft Company, Inc., Santa Monica, California but see 63A10101 + 63A16118

SOURCE: Engineering Paper No. 1478, September, 1962, 19 pp., Missile and Space Systems Division, Douglas Aircraft Company, Inc., Santa Monica, California

PURPOSE: To develop formulas for obtaining the reliability of a system over a set of possible life histories.

ABSTRACT: A previous paper (see Abstract and Review Serial Number 1104) treated the case of a stress-strength model where the strength is independent of time, i.e., there is no cumulative damage due to stresses. This paper extends the analysis to time-dependent strengths. Failure occurs when the applied damage exceeds the strength of the part.

REVIEW: The article is difficult to follow. The theory of cumulative damage appears to be incomplete in that the "ultimate strength" of a part decreases as damage accumulates, but the two are difficult to combine into a single parameter. Much of the mathematics seems to be pointless since the rules of probability theory are well established. Much of the discussion appears still to be concerned with the case of no cumulative damage, although time-varying strengths are considered. As with the earlier paper, the main contribution seems to be in the presentation of a stress-strength model of failure. This paper was published two years ago and perhaps a more organized discussion of the model is now possible. ##

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62N17710

Serial Number 1733
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Small specimen data for predicting life of full-scale structures

AUTHOR: Clarence R. Smith, General Dynamics/Convair, Fatigue Laboratory, San Diego, California

SOURCE: 21 pp., presented at the Fourth Pacific Area National Meeting of the American Society for Testing and Materials (1916 Race Street, Philadelphia, Pennsylvania), Los Angeles, California, October, 1962, General Dynamics/Convair ERR-SD-174, Paper No. 54
see also 64N12811

PURPOSE: To present a method for simple calculation of fatigue life.

ABSTRACT: This paper presents a method for predicting the fatigue life of a full-scale structure for any combination of loading provided that a single data point representing the life of the structure for 10^4 or fewer cycles is known. The only additional information required is stress-strain and SN data for smooth axially loaded coupons.

The following four assumptions are made in the derivation:

1. Fatigue failure of a structure will always occur at a stress concentration.
2. Strain at a concentration will be proportional to load, even though localized yielding occurs.
3. Localized yielding will result in a residual compressive stress at the concentration after load is removed, provided that the adjacent material is still unyielded.
4. Fatigue damage will be accumulated at a linear rate with reference to stresses causing failure at constant amplitude.

The single constant amplitude test must be at a load sufficient to cause yielding at a stress concentration. The stress maximum during the stress cycle is then assumed to be about the yield stress and the stress ratio is determined from the material SN curves and the result of the single test. The rest of the analysis is straightforward.

REVIEW: The method appears to be quite reasonable, and one example of its success is given. The kinds of situations for which the model is adequate will be hard to determine, but those well versed in the field will be able to make intelligent estimates. It will be best for the novice to get help.

The presentation is by an example and is somewhat difficult to follow, but the essential points are presented in above ABSTRACT.

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Serial Number 1734
ASQC Code 810

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Managing a reliability program

AUTHOR: Dorian Shainin, Rath and Strong, Inc., Boston, Massachusetts

SOURCE: Aerospace Engineering, vol. 21, December, 1962, pp. 64, 92, 93

PURPOSE: To show how a reliability program should be managed.

ABSTRACT: Top management must really want to produce a reliable product if it is to be done. They must instill the proper attitudes in their subordinates and must be sure that the proper types of decisions are being made. The procedures in engineering must be more objective; the designers must think in terms of the most likely ways in which the part may fail. The design must be well reviewed from all angles by a competent group. When prototypes are built, there must be several, so that the variability between units can be judged. Accelerated testing, properly handled, can provide a tremendous amount of knowledge about the properties of the equipment in a short time. The manufacturing groups must learn to understand variations, their causes and cures.

REVIEW: This is a short exhortation to managers. In general its points are well taken, although the distribution of emphasis would be handled differently by other people. It might be well to keep in mind while reading this that management never produced a piece of hardware, reliable or otherwise. All that management can do is see that the proper attitudes prevail and that the required capabilities are present in the plant. ##

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65N85900

Serial Number 1735
ASQC Codes 821;838;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Investigation of reliability characteristics of some complex networks

AUTHOR: James Hurst Stephenson, B. S. A. E., Major, USAF, Graduate Systems Reliability Engineering

SOURCE: 49 pp., Thesis presented to the Faculty of the School of Engineering of the Air Force Institute of Technology, Air University, in partial fulfillment of the requirements for the degree of Master of Science, August, 1963 (DDC AD No. 419114)

PURPOSE: To develop reliability functions for the parallel-series, series-parallel, bridge, lattice, and polygonal networks and to formulate procedures for the use of these functions.

ABSTRACT: The functions for the parallel-series and series-parallel networks were developed assuming equal elements having the open and short-circuit failure modes. The functions are expressed in terms of network dimensions and permit designing a maximum reliability network for given elements. The reliability functions for the bridge and lattice networks were developed for networks composed of unequal elements having a single failure mode. The reduced form of these functional expressions may be used for substitution into more complex network functions and the unreduced forms can be used in reliability calculations or computer programming.

The reliability functions of the first five of the polygonal class of networks were formulated for equal path reliabilities and network reliabilities calculated for $r = 0.9$. It was seen that highly reliable networks can be realized by interconnecting the stations.

It is recommended for further study that a simulation program be written for a general polygonal network of n vertices. It is also recommended that computer subroutines or short programs be written which will use the developed bridge and lattice reliability functions for computing network reliability. (Author in part)

REVIEW: This is a standard treatment of the series/parallel networks, although the optimization is not found in most articles. The other networks are rarely specifically treated although some general analyses naturally include them. The work appears to be good as befits a "Master's Thesis".

It should be firmly kept in mind that a logic circuit is being analyzed--not a physical circuit. Under some circumstances the two may not resemble each other very much. The failure criteria should also be thoroughly understood before the model is applied to real situations. ##

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64N16004

Serial Number 1736
ASQC Codes 711;713

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Structures and materials

AUTHORS: R. R. Heldenfels, NASA Langley Research Center and A. Hurlich, General Dynamics/Astronautics

SOURCE: 4 pp., reprinted from Astronautics and Aerospace Engineering, November, 1963 (NASA Technical Reprint RP-136; NASA accession number N64-16004) original art. 64A10157

PURPOSE: To review some of the progress made in structures and materials during 1963.

ABSTRACT: Significant progress has been made in many areas of structures and materials technology in the past year, but no breakthroughs were evident. There were advances as well in structural analysis and design for all types of flight vehicles. Materials developments encompassed the invention and commercialization of new metallic alloys, glasses, and polymeric materials, and the modification and improvement of existing materials to increase their strength, range of usefulness, and fabricability.

The load-strength model of reliability is very briefly discussed and the limitations of the present approaches are mentioned. The damage caused by meteoroids is not easily assessable with existing knowledge. Advances have been made in ground simulation and analysis of meteoroid impact. Some properties of composite materials are being calculated from those of the constituents. The modes of failure and the effects of flaws are being investigated. Recent developments in high-temperature structures are characterized by design, fabrication and testing of large structural components. The analysis of shell structures has made great strides. A first approximation linearized shell theory has been agreed upon. Shell buckling theory and experiments are also making progress.

Aluminum alloys (with magnesium--5000 series, with copper--2014 alloy) have traditionally been used in fuel and oxidizer tanks. A new aluminum-copper alloy and new aluminum-magnesium-zinc alloys exhibit better mechanical properties. The "maraging" steels are making great strides in the high-strength steels. Titanium alloys and beryllium alloys are being developed and are finding uses. The conventional high-temperature alloys such as Inconel are being improved. Good progress is being made in refractory alloys, refractory coatings and metal-ceramic composites. Glass filaments are improved and boron filaments are being developed. New resins, films and adhesives for higher temperature ranges have been developed.

REVIEW: As the authors point out, this is a "quickie" review for those who want to stay on top of what is happening. It accomplishes its purpose well. ##

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63 N12794

Serial Number 1737
ASQC Code 830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Suggestions for designers of electronic equipment

AUTHOR: --

SOURCE: Navy Electronics Laboratory Reprint Edition, June, 1962 (NASA accession number N63-12794)

PURPOSE: To present check lists for designers of electronic equipment.

ABSTRACT: The checklists are presented under the headings

COMMON DESIGN FAULTS
- Technical Faults
- Human Factors Considerations

DESIGN SUGGESTIONS
- Electrical
- Mechanical
- Thermal
- Maintenance
- Safety
- Man-Machine

HUMAN ENGINEERING FOR DESIGNERS

It is not intended to be complete and in some cases the suggestions may not apply.

REVIEW: Such check lists as this one should be used by designers during their own reviews of their designs. It may be tedious to do so, but success in reliability comes in large part from just such attention to detail. To underestimate its importance is to design unreliable equipment. ##

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63A25138

Serial Number 1738
ASQC Code 838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Redundancy techniques for reliable flight-control computers

AUTHOR: J. J. Fleck, General Electric Company, Schenectady, New York

SOURCE: 25 pp., presented at the AIEE Fall General Meeting, Chicago, Illinois, October, 1962, Paper No. CP62-1385, available from IEEE, Box A, Lenox Hill Station, New York, New York 10021

PURPOSE: To discuss various redundancy techniques as they might be applied to a flight-control computer.

ABSTRACT: Insuring safety of flight in high-performance aircraft requires great advancement in the reliability of flight-control computers. While such improvements are not attainable by component improvement alone, they can be effectively achieved by redundancy. This paper describes a combination of redundancy techniques developed to meet flight-control requirements, using majority logic supplemented by self-combinatorial networks and parity-check error detection. Alternative redundancy techniques are outlined and simple approximate expressions for reliability are derived, showing the reasons leading to selection of the desired combination. Theory of majority logic is explained, and expressions for optimum voter arrangement and resultant reliability are derived. Implementation of a model flight-control computer, now under construction, is explained. Judicious computer organization enhances reliability of the basic nonredundant layout, achieving a mean lifetime of 1500 hours (failure probability of 0.005 for an 8-hour mission). For an 8-hour mission, the redundant computer has an equivalent lifetime of 110 years (failure probability of 10^{-5}). (Author)

REVIEW: This appears to be a good piece of work (not all of the mathematics was checked). It is not very detailed, but the comparisons are interesting and directed toward design engineers. There is a copious supply of references for further reading. (The paper was submitted three years ago and some of the facts may since have changed; nevertheless, the reasoning remains instructive.) It should be noted that this is a paper study with regard to reliability; there are no comparative hardware results. In a private communication the author has stated that equipment based on the concepts described in this paper is now flying. ##

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Serial Number 1739 -1
ASQC Codes 822;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Hints and kinks

AUTHOR: Paul Gottfried, Booz-Allen Applied Research, Inc., Bethesda, Maryland

SOURCE: IEEE Reliability Group Newsletter, vol. 9, issue 3, October, 1964, p. 3

PURPOSE: To put mathematical models in proper perspective.

ABSTRACT: Historically, the most popular mathematical model in reliability work has been the exponential distribution with its implied assumption of constant failure rate. This model is reconciled with observed or postualted "bathtub" forms of failure rate variation in time by specifying that the period of use excludes both the interval of "infant mortality" and the interval of "wearout". Although the exponential distribution appears to have acquired its popularity by virtue of its inherent simplicity and ease of mathematical manipulation, it fortunately has strong physical justification in many instances. However, there have been many cases of unjustified use of the exponential distribution--not only where the "true" distribution was unknown, but even when known physical phenomena suggested other models as more appropriate. This has occurred despite one of the exponential distribution's more interesting characteristics--the tendency for its inability to fit the data to become very apparent even to the naked eye.

The Normal distribution is well-known and has been a natural choice in view of the tendency of many manufacturing processes to yield Normally-distributed product parameters. In reliability work, the Normal distribution has found application in the time domain as well as in the stress-strength domain. The most outstanding flaw in its application has resulted from an unwarranted willingness to apply the Normal distribution as a model for behavior under conditions far removed from the sample data and mean--five, ten or more standard deviations from the mean. Most real-world phenomena refuse to conform with the degree of neatness required by such analyses.

The discovery, in recent years, that observed failure patterns of many items follow neither the exponential nor the Normal distribution has led to the adoption of more flexible models. The Weibull distribution has been embraced by observers of time-dependent failure rates in semiconductor devices and mechanical assemblies. The appeal of the Weibull and other multi-parameter distributions lies in their ability to fit a wide variety of data patterns convincingly. Unfortunately, this ability not only provides models of high descriptive capacity; it also tends to mislead the analyst, who may forget to look for the necessary physical relation-

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ships between the mathematical model and the phenomena it is purported to represent. The unpleasant tendency of such models to suffer unpredictable changes in all parameters when stresses, materials, or processes differ from the original sample makes them very dangerous for extrapolation of any kind.

REVIEW: This is an excellent short readable essay on the subject of failure rate equations and models. It strikes a good balance between tearing down unwarranted enthusiasm and building up a real appreciation for the legitimate uses and values of mathematical models. It is recommended reading for everyone who is seriously working in the field of reliability. ##

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63A24201

Serial Number 1740
ASQC Codes 720;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Welding of electronic modules for the Polaris missile

AUTHORS: G. Allen and J. Wettstein, Polaris Value and Production Engineering, Lockheed Missiles and Space Company, Sunnyvale, California

SOURCE: IEEE Transactions on Product Engineering and Production, vol. PEP-7, September, 1963, pp. 1-7

PURPOSE: To describe an investigation of the problems encountered in the welding of electronic modules.

ABSTRACT: An investigation has been made of the problems involved in the welding of electronic modules. The major areas of study were the following:

(1) Standardizing and reducing the number of materials and material sizes,

(2) Providing cleanliness criteria and developing cleaning methods,

(3) Packaging requirements, and

(4) Inspection techniques.

The investigations offer evidence that nickel, Dumet, and Kovar are weldable lead materials to nickel interconnecting media. To meet standards, separate weld schedules are required for each material and size; moreover, allowable variations in material composition and temper are limited. Continuing study of other essential aspects of the problem is being pursued.

REVIEW: This paper appears to be a slightly modified in-house progress report. Little detailed information is offered. The photographic reproductions in Figures 6, 7, and 8 might mean something to an expert, but are useless to the average reader. ##

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63A 24202

Serial Number 1741
ASQC Code 835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Electronic packaging techniques for Surveyor lunar spacecraft

AUTHORS: A. E. Hawley, E. A. Klein, D. D. Lenhart, and L. R. Shrum, Aerospace Group, Hughes Aircraft Company, Culver City, California

SOURCE: IEEE Transactions on Product Engineering and Production, vol. PEP-7, September, 1963, pp. 38-46

PURPOSE: To discuss the packaging techniques used for the electronics portion of the Surveyor spacecraft.

ABSTRACT: The basic objective of the Surveyor spacecraft mission is to provide a soft landing for scientific instruments on the surface of the moon. The major factors that influenced the electronic packaging techniques were:

(1) Types of electronic functions required for spacecraft and scientific instrument operations,

(2) Environments encountered during the life of the spacecraft,

(3) Use of proven components and circuits, and

(4) Minimum weight and volume to provide for maximum payload capacity in terms of scientific instruments on board, consistent with launch weight restrictions.

The various types of electronics included many circuit types from low-signal-level circuits used in signal processing and command decoding to the relatively high-power-level circuits employed in power management.

A description is given of the three major packaging techniques which were developed. These consist of: a foam sandwich chassis to provide a basic etched circuit board for open form assembly; a T-bar assembly for the packaging of HF lumped-constant circuits; and a modified etched circuit board, cordwood module to provide for the packaging of low-signal-level components.

REVIEW: This is an interesting, well-written paper which will provide worthwhile information to engineers with electronic packaging problems. ##

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63A22509

Serial Number 1742
ASQC Code 830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Feedback for error control and two-way communication

AUTHOR: L. S. Schwartz, Research Division, New York University College of Engineering, University Heights, New York, New York

SOURCE: IEEE Transactions on Communications Systems, vol. CS-11, pp. 49-56, March, 1963

PURPOSE: To survey some recent advances in coding, feedback, and two-way communications, to present some applications of feedback, and discuss existing feedback systems using the principles presented.

ABSTRACT: The author discusses unidirectional and feedback systems, giving a comparison of their rates and complexity. Two alternatives are given for achieving nearly error-free transmission without feedback. These are adapting to the worst conditions, or working against them.

Feedback is proposed as being superior to either of these. Feedback systems are classed as being decision or information feedback, and each is described in some detail, along with a combined system, compound feedback. Coding plus feedback, referred to as a "fail-safe" system, is described in considerable detail.

Up to this point the paper has dealt with one-way communication, and in the final section the author discusses the two-way case briefly. He closes by describing three existing systems, the ARQ system, the AGACS system, and MIT's experimental system.

REVIEW: This is a short state-of-the-art paper, in which the author tutorially discusses then-current theory and gives examples of present practice. It will suffice by itself for the reader who is only casually interested, since it is quite clearly written, and the list of 14 references will serve to guide the interested newcomer, as well as to provide a good checklist for the well-read on the subject. ##

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63A 22698

Serial Number 1743
ASQC Codes 711;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Rigid-foam structures for shock protection of electronic subassemblies

AUTHOR: Brooke H. Anderson, Elastomer and Foams Section, Sandia Corporation (present affiliation: CPR, A Division of The Upjohn Company, 555 Alaska Avenue, Torrance, California 90503)

SOURCE: Electro-Technology, vol. 72, September, 1963, pp. 90-94

PURPOSE: To describe the properties of rigid urethane foams for mechanical protection of parts.

ABSTRACT: In aerospace applications, where electronic modules can encounter shock loads up to several thousand g, mechanical and thermal protection can be achieved by means of rigid urethane-foam support structures, machined or molded to the configuration of components within the assembly. Properties of urethane foams are appraised in terms of mechanical energy absorption, strength-to-weight ratios, dielectric properties, humidity and temperature effects, design flexibility and manufacturing costs.

The foams will protect electronic assemblies quite well, better than many other systems of protection, when properly applied. (Author in part)

REVIEW: This is a good article and deals with an important topic. It does not mention the flexible and semi-flexible urethane foams, nor does it discuss any of the "foam-in-place" practices. It is recommended reading for those concerned with the problem. Several references are given. ##

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Serial Number 1744
ASQC Codes 815;816

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Cross-indexing industry and military specifications and standards

AUTHOR: W. L. Healy, American Standards Association

SOURCE: the magazine of standards, February, 1961 through present

PURPOSE: To present industry standards which can be used for procurement of military items.

ABSTRACT: Since February 1961, the magazine of standards has been publishing brief descriptions of industry and military specifications and standards which are quite alike. Since many materials are readily purchased to industry specifications and standards and not so readily purchased to military specifications and standards, this correlation can assist designers and purchasing agents.

REVIEW: This is an activity which has a favorable bearing on reliability. The procurement of materials which are made to a widely-used standard (either military or industry) which is in common use is more likely to result in a good item than materials for which special handling is necessary. The author encourages correspondence with him about more items for this series. (The work is performed under contract with BuShips.) In a private communication the author has stated that the material is also being published in the Official Navy Publication NavShips 250-350 Chapter 6. ##

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Serial Number 1745
ASQC Code 550

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability slide rule

AUTHOR: Gerald F. Allen, General Dynamics/Pomona, Pomona, California

SOURCE: Electronics, vol. 36, September 6, 1963, pp. 44, 46, 48, 50

PURPOSE: To present a slide rule for making computations of the confidence in estimates of binomial probability.

ABSTRACT: If n tests are run with m successes, the ratio m/n has a probability distribution. The slide rule printed in this paper solves the cumulative distribution problem and thus gives upper and lower confidence limits on the probability of success. It is important to remember that the experimental outcomes must be dichotomized into success and failure. The chi-square approximation to the actual probability density is used and estimates of the error are given.

REVIEW: For rough work, this slide rule is fine; the approximations are quite adequate, especially in view of all the other assumptions usually made in a test program. For exact work, such as in the meeting of specifications, it may be better to resort to more exact methods such as the use of [1].

REFERENCE: [1] Binomial reliability table (lower confidence limits for the binomial distribution) US Naval Ordnance Test Station, 1964 (DDC AD No. 444344) ##

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Serial Number 1746
ASQC Codes 711;712;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Determining the response threshold with respect to cycles for fatigue tests on aluminum alloys

AUTHOR: M. N. Stepnov, Moscow Institute of Aviation Technology

SOURCE: Industrial Laboratory, vol. 28, pp. 884-886, January, 1963 (Translated from Zavodskaya Laboratoriya, Vol. 28, No. 7, pp. 836-838, July, 1962)

PURPOSE: To derive a formula for easily calculating the probability of fatigue failure for a given stress.

ABSTRACT: Based on a correlation analysis of fatigue test results, formulas have been obtained for an indirect determination of the response threshold with respect to cycles for aluminum structural alloys so that it is possible to plot fatigue curves at small probabilities of failure, including zero, with a limited number of test specimens.

It is assumed that log $(N-N_o)$ has a Gaussian distribution where N_o is an empirical parameter and N is the number of cycles to failure. The parameters of the Gaussian distribution are functions of stress. For the alloys under consideration, it is shown that log N_o = 0.86 x(arithmetic mean of log N_i, i = 1, ..., n) is reasonable. From a few points, the value of the mean log N_i can be determined and thus N_o can be calculated. Obviously N_o is the greatest lower bound for cycles to failure.

REVIEW: The paper is somewhat difficult to read since the notation is not familiar. The formula for log N_o is obviously a rather gross approximation as seen from the data illustrating it. Even ignoring that point, it is obvious that the fit of the original model--log $(N-N_o)$ is Gaussian--is not known in the tail regions. Therefore extreme caution should be used before treating the results as anything more than an engineering approximation. ##

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Serial Number 1747
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Evaluating the probability of failure in fatigue tests

AUTHOR: M. N. Stepnov, Moscow Institute of Aviation Technology

SOURCE: Industrial Laboratory, vol. 28, pp. 886-888, January, 1963 (Translated from Zavodskaya Laboratoriya, Vol. 28, No. 7, pp. 838-839, July, 1962)

PURPOSE: To propose a formula for assigning probabilities in small samples.

ABSTRACT: For ordered data, one usually assigns the probability m/(n + 1) to the m th observation out of n. A better formula is (m - 1/2)/n. It is shown to fit fatigue data better for Gaussian distributions of the logarithm of cycles to failure.

REVIEW: There are many viewpoints on this subject and there is usually little to choose between the various formulas, based on engineering judgment. For small samples there is bound to be scatter to confuse the issue; for large samples there is little difference between the results given by the different formulas. Therefore, most arguments (including this one) on which formula to use are trivial from an engineering point of view. ##

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Serial Number 1748
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Effect of the frequency of load reversals on service life of duralumin

AUTHOR: V. I. Shabalin

SOURCE: Industrial Laboratory, vol. 28, pp. 903-905, January, 1963 (Translated from Zavodskaya Laboratoriya, Vol. 28, No. 7, pp. 855-857, July, 1962)

PURPOSE: To describe the effect of cycling frequency on the fatigue life of duralumin.

ABSTRACT: The specimens were of D16T duralumin and were for rotating beam tests; some were notched 0.75 mm deep and 0.75 mm in radius; the others were smooth and polished. The test diameter was 8 mm. The frequencies were 20 and 3000 cycles/min; tests were all stopped at 1.5×10^6 cycles. The life was improved at all loads, but much more so for the notched specimens; the factor of improvement was as high as 38 and has a maximum at about $22 kg/mm^2$.

REVIEW: It is generally considered that frequency (within these limits) has little effect on fatigue life as long as heating is not a problem. No mention is made of heating which might have been present at 50 cycles/sec of the high speed tests. Average curves are shown with no indication of scatter in the results. There are two misprints: (1) in one place the low speed is given as 200 c/min, and (2) the units for the N scales are given as "min", which should be "million".

There is no reason to doubt the actual results given here, although no explanation is offered for the behavior. ##

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Serial Number 1749
ASQC Code 711;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Insulation in electronics

AUTHOR: Reuben Lee, Consulting Engineer, Electronics Division, Westinghouse Electric Corporation, Baltimore 3, Maryland

SOURCE: Insulation, vol. 9, September, 1963, pp. 20-22

PURPOSE: To give a state of the art review of electronic insulation.

ABSTRACT: The major materials and processes used in the insulation of modern electronics are discussed. Resins continue to be used extensively for casting, molding, and encapsulating electronic components. Flexible epoxies have been used where rigidity would ultimately result in the failure of parts. The use of silicones continues. The operational temperature range of inductive components can be extended through the use of the recently-developed aromatic polymers. For commercial applications, polyester resins continue to be used widely because of their low cost; filled resins have been developed for special purposes. In space satellites, rigid polyurethane foam is used to embed micromodules; the rigid foam may be covered with a resilient coating. Use of the new insulating fluids, both fluorocarbon and silicones, continues as more of these fluids are tested.

Ceramics remain among the most useful insulating materials because of their ability to withstand compressive stresses, high temperatures, and high voltages. Effort has been expanded in the development of machinable ceramics and organic substitutes for ceramics. For some purposes ceramics must be supplemented by cushioning gaskets of compressible materials such as "Teflon" PTFE, "Viton" synthetic elastomer, or neoprene rubber. The choice of insulating materials for printed circuit boards normally falls on phenolic laminate for the consumer market with the more expensive epoxy-glass laminate being used by the military. A recent development comprises parallel strand glass fiber laminates of superior mechanical strength. Examples are given of various applications of modern insulation techniques; these include a miniaturized computer element, and a 15 kw wide-band balun. Present work is being directed towards the development of components that are well protected against electric breakdown, corona, pressure, temperature, and radiation. Future trends are towards molecular electronics, the use of ferroelectric materials for energy conversion, and the reduction of radiation effects on insulation.

REVIEW: This paper is for the man who does not have the time to read a detailed review. The author treats the highlights of his subject and gives very few details. The list of references is inadequate for a review paper. ##

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Serial Number 1750
ASQC Codes 711;833;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Ceramic dielectrics

AUTHOR: Per A. Larssen, Senior Research Scientist, Aeronutronic Division, Ford Motor Company, Newport Beach, California

SOURCE: Insulation, vol. 9, September, 1963, pp. 27-32

PURPOSE: To give a state of the art review of ceramic dielectrics and their uses.

ABSTRACT: Ceramic dielectrics can conveniently be divided into two main categories: those used for insulation purposes only, and those which perform various electronic functions. Most of the common ceramic insulators are still found within the magnesia-alumina-silica phase diagram. Other less conventional ceramic insulating materials have been developed for special applications; these include zircon, wollastonite, beryllia, zirconia, and thoria. Some of the binary compounds of interest are boron nitride, silicon nitride, various sulphides, selenides and tellurides, halides, phosphides and carbides. In general the best electrical insulators among them are those where the constituent elements have a large difference in electronegativity.

Of the materials used for the electronic functions the "non-linear" ceramic dielectrics are characterized by the non-linear relationship between the electric field and displacement; in addition the dielectric constant and other properties are highly temperature-dependent. In this field new materials and new material mixtures use various combinations of barium titanate with lead stannate and zirconate or bismuth compounds.

Highlights of each major application which demonstrate the state of the art are pointed out. Examples are given of uses in the following areas: high frequency insulation, electron tubes, spark plugs, ceramic encapsulation, resistors, transformers, miniaturized printed circuitry, switchgear and control apparatus, and ceramic insulated wires and cables.

A short review is given of current research work in ceramics.

REVIEW: This paper is suitable for the person who wishes to acquire a good overall picture of recent developments in the field of ceramic dielectrics. The person who would like to have some detailed information in addition to the outline will be frustrated by the lack of keyed references. This type of state of the art review cites only general references. ##

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Serial Number 1751
ASQC Codes 711;720;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Thin film dielectrics

AUTHOR: P. White, Standard Telecommunication Laboratories Ltd., London Road, Harlow, Essex, England

SOURCE: Insulation, vol. 9, September, 1963, pp. 57-66

PURPOSE: To give a state of the art review of thin film dielectrics.

ABSTRACT: The main available techniques for the fabrication of dielectric films are reviewed and discussed in relation to those currently being used for the fabrication of other elements. It is maintained that, in general, thin dielectric films are used for two purposes: (1) as dielectrics in the fabrication of capacitors and inductors, and (2) for their insulation properties in situations where the dielectric layer acts as a spacer between metal films or as a protective layer over a completed circuit. Current areas of scientific and industrial interest are briefly considered.

The films are divided into two groups: (1) films of inorganic materials, and (2) films of ceramic or organic materials. Topics considered in the discussion of the first group are (a) films formed by interaction of a gas with the underlying solid, (b) oxide films formed by anodization, (c) evaporated dielectrics, and (d) reactive sputtering. The discussion of the second group covers techniques for the formation of glass, ceramic, and organic films by vacuum evaporation, and spreading techniques. In the latter the films are formed by spreading a powdered solid, liquid, or gas over the substrate and subsequently transforming the layer to the solid state by the application of heat, radiation, or some alternative method. The formation of ceramic or organic films by vapor deposition and subsequent polymerization through thermal reaction, ultraviolet light, electron beams, or a gas phase discharge is reviewed. The properties of the dielectric films are compared with those of the bulk material; the special effects observed with thin films are mentioned.

REVIEW: The direct bearing of this topic on the day-to-day work of the reliability engineer is quite small, but its indirect bearing is very great. Those concerned with the reliability of electronic components need to know something of the properties of the constituent materials. This paper is suitable for the person who has some knowledge of thin film dielectrics and needs to know more.

Better editing and a more imaginative format would have improved the paper. The inclusion of more figures of a technical nature would have helped. The date cited in reference 19 should be 1858 not 1958; reference 10 should read "Journal de Chemie Physique" instead of "Journal of Chemical Physics." ##

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Serial Number 1752
ASQC Codes 770;782;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Determination and application of thermal-life characteristics of aerospace wires--Parts 1 and 2

AUTHORS: F. J. Campbell and E. L. Brancato, U. S. Naval Research Laboratory, Washington 25, D. C.

SOURCE: Insulation, vol. 9, October, 1963, pp. 17-22 and November, 1963, pp. 23-30

PURPOSE: To describe experiments leading to the determination of thermal-life characteristics of insulated wires.

ABSTRACT: A practical method has been evolved for the evaluation of thermal-service characteristics of aerospace wires. This method allows each variation in construction and materials of a particular class of wires to be evaluated, and its thermal stability to be compared with a standard of performance.

In the experimental studies a set of 10 specimens of each wire type was prepared for evaluation of life at each temperature point. The 10 wires were positioned in standard mounts which provided convenient handling throughout the test cycle. The tests consisted of: (1) heat exposure in which temperatures were selected to give life periods of approximately 2500, 1000, 250, and 100 hours so that a life versus temperature curve would be obtained for each type of wire, (2) mechanical stress in the form of a standard mandrel bend, (3) humidity exposure in which the samples were subjected to 100% relative humidity in preparation for the electrical test, and (4) a 3000-volt rms test voltage applied to the humidified insulation after each aging cycle.

As a result of this work a useful calculation technique was developed for totaling cyclic heating effects, so that more reliability and weight economy can be designed into any aerospace vehicle's electrical system. In addition much useful information about many classes of wires presently used in aerospace installations was obtained and is presented in the paper.

REVIEW: The authors have given a detailed account of their investigation of the thermal-life characteristics of aerospace wires. This is a good scientific paper on a topic of importance to all people concerned with the reliability of insulated wires. ##

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Serial Number 1753
ASQC Codes 782;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Current carrying capacity of hookup wire

AUTHOR: Joseph C. Reed, E. I. du Pont de Nemours & Company, Wilmington 98, Delaware

SOURCE: Insulation, vol. 10, January, 1964, pp. 40-43

PURPOSE: To present information on the current carrying capacity of hookup wire.

ABSTRACT: The minimum wire size for many applications has often been determined by the physical strength of the conductor rather than by electrical and thermal considerations. The recent introduction of high-strength alloys for current-carrying conductors has encouraged the use of smaller conductors without sacrificing mechanical strength. Although, in certain conditions, the use of smaller conductors may cause conductor temperatures to exceed the thermal rating of low-temperature insulations, the use of small conductors may be satisfactory with modern high-temperature insulations.

Calculations have been made which relate maximum allowable steady-state current to maximum conductor temperature, wire size, and ambient temperature. The calculations were made for two insulation thicknesses (10 and 15 mils), a range of ambient temperatures from 0 to 260°C, and conductor temperatures from 105 to 260°C. Several wire gages from 12 through 30 were considered.

Graphs are given for maximum conductor current as a function of temperature rise above ambient, as well as for insulated wire weight as a function of insulation density. The maximum allowable temperatures for various insulations are tabulated. A tabular comparison is made of the current carrying capacity, conductor size, and weight of insulated wire with 10-mil insulation at 100°C ambient.

REVIEW: From the point of view of reliability, the essence of this paper is contained in Figures 1 and 2 in which maximum current is plotted as a function of temperature rise above the ambient. However, it is important to note that these are calculated values and the author does not support his calculations with any experimental evidence.

In a private communication the author has stated that the values shown were calculated by industrial standards, namely Electronic Industries Association Standard RS-214, Method for Calculation of Current Ratings on Hookup Wire, November 1958. ##

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Serial Number 1754
ASQC Codes 711;833;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Lightweight, soluble encapsulating compound permits repair of electronics

AUTHOR: R. M. Steigerwald, Reliability Manager, The Sippican Corporation, Marion, Massachusetts

SOURCE: Insulation, vol. 10, February, 1964, pp. 35-38

PURPOSE: To describe a new kind of encapsulating compound.

ABSTRACT: The major criteria considered during selection of an encapsulant for a particular application include compressive strength, shrinkage, thermal conductivity, moisture resistance, weight, and repairability. These last two criteria have become increasingly important with the demand for weight reductions in pay-loads and maintainability of encapsulated modular electronics.

As a result of an investigation of lightweight encapsulation compounds that will permit the repair of electronics, a jacketed microballoon encapsulant has been developed which gives excellent strength and thermal properties while furnishing an extremely lightweight and repairable system. The core of this encapsulant consists of glass microballoons with acetone as the carrier and polyvinyl butyral as the binder. The compound is one fifth as dense as the lightest standard-filled epoxy. The repairability requirement is also fulfilled because the microballoon binder is readily soluble in acetone.

In actual use the encapsulant is jacketed with epoxy material to insure that the entire package conforms to military requirements on moisture absorption and compressive strength. This "three-part" encapsulant--core, sealer, and jacket--provides one possible solution to critical weight and repairability problems inherent in many military electronics applications.

REVIEW: The author has given an interesting description of experimental work with the new type of encapsulant. The paper is well-written and contains much useful information in a limited amount of space. ##

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Serial Number 1755
ASQC Codes 711;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A summary of solvents for in-place electrical cleaning and their effects on several insulating materials

AUTHORS: W. D. Schultz and W. U. Seiler, The Dow Chemical Company, Midland, Michigan

SOURCE: Insulation, vol. 10, April, 1964, pp. 42-45

PURPOSE: To describe the results of tests to determine the effects of certain solvents on a variety of insulating materials.

ABSTRACT: Periodic cleaning of electrical equipment by a suitable solvent removes electrically conducting contaminants which can render equipment inoperative; in addition, moisture is removed by displacement thus reducing the danger of moisture grounding. Cleaning with a solvent also removes oily, greasy solids which can accumulate and pose a fire hazard or restrict passages for cooling air.

Factors affecting the choice of a solvent are discussed; these include the ability of the solvent to remove soil without deleterious effects to the equipment, the inflammability, and the toxicity of the solvent.

The insulating coatings and varnishes for this study were selected to provide a representative cross-section of insulating materials in common use; they included clear and pigmented alkyd resins (glycerolphthalic acid polymers), oil-phenolic, and oven-drying asphaltic types.

To study the effects of chlorinated solvents on the insulating varnishes, copper panels two inches wide and five inches long were immersed in the insulating materials and then air-dried or oven-baked as recommended by the manufacturer. After the appropriate curing operations the panels were immersed in solvent. The effects of the solvent upon the insulating material were then noted.

Test results are given which show the effects of Chlorothene NU, Dowclene EC, and perchlorethylene on the various kinds of insulation. It was found that methylene chloride could not be safely used with the insulations tested.

REVIEW: This should prove to be a useful paper to the electrical engineer with cleaning problems. The authors have managed to condense a large amount of information into a small space. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability models--basis for programming quality and reliability tasks

AUTHOR: Ernest P. Cupo, Jr., Minuteman Reliability Department, TRW Space Technology Laboratories, One Space Park, Redondo Beach, California

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 1-9

PURPOSE: To discuss the potential of reliability models as a managerial aid.

ABSTRACT: In establishing a reliability program, it is important to make knowledgeable trade-offs of the tasks and techniques to be applied to a particular program with respect to their effectiveness and timely accomplishment. A reliability model is one of the most effective tools which may be used by management in its original planning and for continuous direction of the reliability program during all phases of product development and use. Such a model allows the utilization of dollars and effort at the most significant points and at the most effective time.

This paper mentions the principal uses of reliability models as a managerial aid in the following evolutionary phases of a major system:

Unsolicited proposal
Solicited proposal
Initial design
Breadboard test and design evaluation
Production
Operational
System follow-on proposals (Author in part)

REVIEW: This paper does not convey a very specific idea of just what the author means by "a reliability model," except possibly to those who are already familiar with the term in this context. To the mathematician/statistician a model is a mathematical expression; to the engineer it could well be a mock-up of a system. In this paper it is apparently neither of these, but rather "a systems analysis which considers specified characteristics of a system in a disciplined way." In view of this, it would seem better, from the standpoint of most readers to replace "reliability model" with "reliability assessment system," or some such expression. Similarly, it would have improved the paper considerably if an example or short case history had been included. No doubt an effective means of reliability measurement can contribute a lot at every phase in the evolution of a system. The author has, in effect, brought this out in rather general terms. ##

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Serial Number 1757
ASQC Code 732

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability and the life test

AUTHOR: Irvin R. Whiteman, Director of Operations Analysis and Research, Computer Concepts, Inc., Los Angeles, California

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 31-38

PURPOSE: To discuss the importance of a sound data base and suitable models in reliability prediction.

ABSTRACT: The most important question is, "What is the most reliable design?" It can only be answered based upon a knowledge of failure rate as a function of the expected environment. There can be little doubt that the problem of component failure rates is among the most pressing of all problems in the field of reliability. Without good data, the validity of the reliability prediction is, at best, questionable. Two objectives are clear: 1 -- the creation of a more comprehensive data base to facilitate better reliability prediction and 2 -- the provision of a prototype set of failure rate models to serve as a guide to those concerned with the acquisition and presentation of basic failure rate data.

Topics discussed include the general and specific goals of life testing, the importance of good data, the role of functional relationships, the distinction between independent and dependent events, and the importance of computer methods in reliability prediction. It is indicated that a methodology must be developed for presentation of data, and for updating failure rate listings. Updating should take into account such questions as whether new data departs significantly from the existing model, whether new estimates of the parameters indicate that listed values should be revised, and whether a new functional form should be postulated. (Author in part)

REVIEW: This paper is a rather general discussion of the need for adequate data and the role of models in reliability prediction. It conveys impressions rather than technical details. For instance, the reference to the Arrhenius law (on p. 35 in the paper) is rather loosely worded and should not be taken as a technically accurate statement. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Airplane reliability demonstration

AUTHOR: Wendell W. Harter, Norair Division, Northrop Corporation, Hawthorne, California

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 39-45

PURPOSE: To discuss the reliability demonstration test program for the T-38 airplane.

ABSTRACT: Ground rules for conduct of airplane reliability demonstration tests are of major significance to the test results. It is therefore essential that careful consideration be given in their formulation, and that this be accomplished to the mutual satisfaction of the customer and contractor well in advance of initiation of the tests. Success criteria must be defined in the demonstration test plan in sufficient detail to avoid possible differences in interpretation of the measured data, and must be consistent with the established contract reliability requirements. It follows that the latter should be specified in terms which can be measured at reasonable cost and with acceptable confidence. The application of these principles is illustrated by a discussion of the T-38 Talon airplane reliability demonstration test plan and its implementation.

The philosophy employed in the choice of the reliability demonstration method is discussed. The reliability demonstration test plan is described. Test results are summarized. (Author in part)

REVIEW: This is a good brief description of a particular reliability demonstration test program. The emphasis is on the philosophy of the test plan, the principal features of the plan, and the method used for the analysis of the test results. Greater detail on the latter two areas may no doubt be found in two of the three references cited in the paper. The paper should be of interest to those formulating reliability demonstration test plans for similar products. ##

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Serial Number 1759
ASQC Code 523

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Variation research--a tool for material reliability programs

AUTHOR: Leonard G. Johnson, Research Laboratories, General Motors Corporation, Warren, Michigan

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 47-54 (also Society of Automotive Engineers paper 893C)

PURPOSE: To illustrate the use of variation research in materials testing.

ABSTRACT: The testing of materials involves the evaluation of the contributions made by various factors to the quality of a product. In order to say that a factor is important or irrelevant, we must have, among other things, a sound statistical basis for such a statement. The technique of variation research, which makes use of probability paper plots, demonstrates the statistical ideas of significance in a fashion easy to understand and easy to interpret. An exposition of the main points of variation research in materials testing is presented in this paper.

A complete factorial experiment involving three factors at two levels each is described. The factors represent ingredients (A, B, and C) which are either present or missing, and for each combination the experimenter determines the life of the part by testing it to failure. Observed life is measured in cycles to failure. For the evaluation of the A effect, the results are separated into two parts: those for which A is present, and those for which A is missing. The two samples are compared for a significant difference at the mean life level using order statistics, by plotting on Weibull probability paper. Analysis of the B and C effects would be made similarly. For the analysis of the AB interaction, the results are separated into two parts consisting of those for which A or B (but not both) is present, and those for which both A and B are present or neither A nor B is present. Calculation details are shown. (Author in part)

REVIEW: This paper serves its purpose quite well as an illustration of a practical method of data analysis in the case of the 2^3 factorial experiment. The method is a convenient way of displaying and assessing main effects and interactions. As such, it will be preferred by many to the conventional analysis of variance. The paper does not go into the background or theory; a reference is cited. Those interested in more detail or in more sophisticated applications should consult the reference. It should be emphasized that a statistically significant effect (discussed here) may or may not have engineering significance, and vice-versa. ##

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Serial Number 1760 -1
ASQC Codes 840;850

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Programming and analysis of a reliability test on tantalum foil capacitors

AUTHOR: F. R. Cogen, Research Division, The Hydro-Electric Power Commission of Ontario, 200 Kipling Avenue South, Toronto 18, Canada

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 65-76

PURPOSE: To describe the planning and programming of a large-scale reliability test on tantalum foil capacitors.

ABSTRACT: The Canadian Military Electronics Standards Agency (CAMESA) instituted a reliability test program which has been in operation for about four years. A small number of large-scale reliability tests on resistors and capacitors are now in progress or are drawing to a conclusion. This paper describes one of these tests on tantalum foil capacitors. Emphasis is placed on the planning and programming of this test. Methods of data reduction and data analysis are given and the impact on product improvement is discussed. The equipment used is described in general terms.

The reliability test discussed in this paper entails a 10-cell test matrix on 2280 tantalum foil capacitors. Much of the planning and programming of the test would apply to a variety of component parts. Because the paper deals with methods of test and analysis, the make of the component part is of no great importance and the manufacturer's name is omitted. It may be mentioned however, that the manufacturer lent whole-hearted support to this program, and has obtained from it information helpful in component part redesign. The tantalum foil capacitors tested conformed with Specification MIL-C-3965B, which was used wherever necessary. Test procedures were governed by a CAMESA manual: "Reliability Testing Program on Electronic Parts."

The test was designed to provide reliability data from application of standardized voltages and temperatures, including rated and overrated conditions. Failure-rate data were primarily desired. Because of variable failure rates, the hazard rate and confidence limits about the hazard rate were calculated and plotted. Failure mechanisms were analyzed statistically and observed physically. Three distinct failure stages were observed by fitting three-component composite Weibull distributions: infant mortality, useful life and wearout. Distinct differences in manufacturing processes between the two capacitor values tested were noted and analyzed. As a result, capacitor design and manufacturing processes were modified. Generally, infant mortality was too high for both the 6-μf capacitors and the 10-μf capacitors. Otherwise,

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only the 6-μf capacitors could be assumed reliable. (Author in part)

REVIEW: This is a quite detailed account of the particular test program described. As such, it could be helpful to those concerned with the planning and implementation of similar programs. As the author has indicated, the approach would be applicable to the testing of components other than capacitors. (An earlier paper on the CAMESA reliability test program was covered by Abstract and Review Serial Number 236.)

The author, in a private communication, has pointed out that the variance formula appearing at the top of page 74 in the paper is incorrect, and that interested parties may contact him to receive the corrected formula.

The use of three Weibull distributions with two parameters each to fit a single set of data allows six parameters to be adjusted to the data. Many functions with six adjustable parameters would fit the data as well or better. For a discussion of this point see the paper covered by Abstract and Review Serial Number 1781. In general, the choice of model requires careful thought, and the more sophisticated the model the greater is the need to examine the data and implications. For a more complete discussion on this see the paper covered by Abstract and Review Serial Number 1739. ##

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Serial Number 1761
ASQC Codes 300;813;815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Program provisions of NASA reliability and quality assurance publications

AUTHOR: John E. Condon, Office of Reliability & Quality Assurance, National Aeronautics & Space Administration, Washington, D. C.

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 89-92

This paper is very similar to the one covered by Abstract and Review Serial Number 1495, by the same author. While the two presentations are not identical, essentially the same Abstract and Review pertains to both. ##

Serial Number 1762
ASQC Code 851

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Attaining confidence in spacecraft reliability

AUTHOR: Walter R. Kuzmin, Space Systems Division, Hughes Aircraft Company, El Segundo, California

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 101-117

PURPOSE: To present a spacecraft test program based on all available test data for use in demonstrating a reliability objective.

ABSTRACT: Limited production quantities of spacecraft restrict the full acquisition of independent sample sizes for reliability testing. This places serious constraints on the determination of reliability, by test, at specified confidence levels. Attainment of an 80 per cent confidence level regarding reliability estimates by analytical-technical conversion of all available test data to equivalent mission cycles (EMC) is presented as a means of overcoming the above-mentioned constraints.

An underlying exponential distribution of times-to-failure is assumed, together with statistical independence between components. Advantage is taken of all tests performed (including developmental, type approval, flight acceptance, qualification, and other tests). The data, after evaluation for suitability, are converted into EMC. A procedure is given for determining the sample size, n, in terms of EMC, necessary to demonstrate required reliability with stated confidence for a spacecraft of N subsystems. Some of the procedures used in data utilization are outlined. Criteria used in the categorization of failures are given. Advantages of the use of the EMC program are summarized.

REVIEW: This is a somewhat more complete discussion of the topic of the paper covered by Abstract and Review Serial Number 1528. It provides more detail on the working of the EMC program. However, the procedure for determining the necessary number of equivalent mission cycles to demonstrate reliability with stated confidence is neither derived nor specifically referenced in either paper.

The idea of using all pertinent available data in order to overcome the constraints on time, material, and money in reliability testing is good. The screening of the data for suitability as representing EMC is very important. It is also important to be sure that all of the underlying assumptions are essentially satisfied. Otherwise, the advantages of the use of the program may be more apparent than real. ##

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Serial Number 1763
ASQC Code 840

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Analysis--meeting point for reliability and quality control

AUTHORS: W. P. Hart and L. G. Rado, ITT Cannon Electric Inc., 3208 Humboldt Street, Los Angeles, California 90031

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 153-159

PURPOSE: To discuss the interrelated analysis techniques used by reliability and quality control groups.

ABSTRACT: One of the more recent trends is to incorporate Reliability and Quality Assurance Sections into the Product Assurance or Product Effectiveness groups. Product Assurance or Product Effectiveness is the terminology used to combine the reliability and quality segments under one group head. The meeting ground has usually been due to an absorption of functions rather than through technical amicability--where one function enhances the other. This paper covers that meeting ground where the ground rules are not formed out of a management textbook, but rather are based on standard statistical handbooks. Quality assurance dedicated to a check of the product and reliability dedicated to life assurance use virtually the same techniques to evaluate parts. This paper discusses these interrelated techniques.

Some of the results of combining the analysis problems of quality control and reliability and of using computers to automate the tedious calculations are:

1. Data displays for incorporation into new specifications for connectors.
2. Rapid reduction of line and laboratory data.
3. Doing the job more quickly at less cost.
4. Expansion of routines to take care of in-plant practices.
5. Standardization of reports from the quality control and laboratory areas, together with reduction in the costs of producing reports.
6. The releasing of technical people to do technical work (by freeing them from the labor of routine calculations).

(Authors in part)

REVIEW: This is not a detailed discussion of analysis techniques which reliability and quality control use in common--as might be inferred from the title and the authors' abstract. The paper does, however, serve a useful purpose in presenting the advantages of combining the analysis functions for the two groups, and of using computers to perform the routine functions. These advantages are clearly brought out, and are worthy of the consideration of managers interested in improving the efficiency of their groups. ##

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Serial Number 1764
ASQC Code 810

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Effectiveness planning for reliability programs

AUTHOR: Phil I. Harr and James Rusk, Jr., General Dynamics/Astronautics

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 165-174

PURPOSE: To examine the question of getting the most effectiveness out of each procurement dollar spent on reliability assurance effort.

ABSTRACT: The aerospace industry is pressed to provide more for each dollar spent. Reliability, a key element in cost-effectiveness, is a significant part of overall procurement cost. It is increasingly important to get maximum reliability for effort expended. By allocating funding according to criticality and failure experience, effort is concentrated where it is needed most. Analyzing the design to determine which types of assurance activity promise the greatest returns, the reliability program can be planned for maximum reliability/cost-effectiveness. An example, modified from recent General Dynamics/Astronautics experience, is presented to illustrate the principles involved. (Authors)

REVIEW: This is a good brief discussion of cost-effectiveness planning based on the experience of one company. The presentation through the medium of an example (modified enough to avoid specific identification) is more effective than if it had been based only on generalities. Managers concerned with cost-effectiveness should find ideas in the paper which are adaptable to their own situations. ##

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G

Serial Number 1765
ASQC Codes 412;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability-life test analysis using the Weibull distribution

AUTHORS: N. Kaufman and M. Lipow, TRW Space Technology Laboratories, Redondo Beach, California (N. Kaufman now with Hughes Aircraft Company, Space Systems Division)

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 175-187

PURPOSE: To show that the usual binomial upper confidence limits can be improved when a distribution assumption is made.

ABSTRACT: This paper presents a method of analyzing life or stress-to-failure tests under the assumption that the time(stress)-to-failure follows a three-parameter Weibull distribution. The method yields a system of upper confidence limits on the probability of failure on or before required life, with stated confidence coefficient. It is an improvement over the usual binomial upper confidence limits by virtue of the assumption of a Weibull distribution. It appears particularly suited to the situation where a small probability of failure for a given stress level must be demonstrated with a high confidence.

When the analysis is based on the binomial distribution, the only data used are the observed numbers of "successes" and "failures." When it is desired to utilize the additional information contained in the actual times at which failures occur, some assumption must be made regarding the distribution of time-to-failure. In this paper it is shown that if the underlying distribution is a three-parameter Weibull, then a system of upper confidence limits can be constructed which are uniformly smaller than those based on the binomial distribution. Proof of this theorem and a more general one are given in appendices. The main text defines the system of upper confidence limits and presents some examples. Appropriate tables for computing the confidence limits are included.

REVIEW: This is a well-organized paper which presents and illustrates a useful mathematical result. For those who do not wish to go into the mathematical details, but are interested in the result and its application, the main text is sufficient. Pertinent references are cited. Care should be exercised in extrapolating to very small failure probabilities since the results may be rather sensitive to the assumed distribution.

Other papers dealing with the Weibull distribution and various aspects of its role in reliability analysis have been covered by Abstracts and Reviews Serial Numbers 320, 437, 499, 749, 751, 801, 848, 1015, 1171, 1435, 1453, 1473, 1538, 1578, and 1701. ##

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National Aeronautics and Space Administration
Washington, D. C. 20546

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Controlling high reliability production

AUTHORS: J. R. Rossie, Semiconductor Products Division and E. L. Tinnes, Solid State Systems Division, Motorola, Inc.

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 203-208

PURPOSE: To describe the principles and techniques essential to controlling the production of high-reliability semiconductors and thin film microcircuit devices.

ABSTRACT: Achieving a high level of reliability in the semiconductor or thin film industry is directly related to achieving an effective system of process controls. In order to achieve this level of control, two principles of process control must be considered.

(1) The highest level of process control is achieved by the simplest and most direct controls.
(2) The shortest and most effective control loop is realized by using the operators' desires to excel.

It is assumed that a high reliability production program is one which has the following elements: (1) established and documented production processes, (2) production process controls, (3) in-line inspection and control, (4) lot identification and traceability, (5) classical reliability tests on each lot, and (6) a closed-loop failure analysis system.

In-process inspection is responsible for maintaining a system by which changes in the production process can be detected and reported on a daily or even hourly basis. The significance of the change is evaluated by the process engineer and the reliability engineer. Three types of changes may be encountered: controllable, induced, and unknown. The basic techniques in establishing process controls are outlined with reference to these types. Areas of process control research include developing new process control techniques and testing for adequacy of process controls. These are described briefly; other topics considered include simplifying controls for operator use and reporting. (Authors in part)

REVIEW: This is a concise presentation in which the main points under each heading are enumerated; little elaboration is given. It should be useful to those who are planning process control programs, as a listing of things to remember/watch out for. Details of implementation in specific situations will remain to be worked out. ##

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Serial Number 1767
ASQC Codes 821;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Analytical contributions to system reliability

AUTHORS: William S. Connor and Charles A. Krohn, Statistics Research Division, Research Triangle Institute, Durham, North Carolina

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 209-218

PURPOSE: To outline the results of an effort to develop a basic mathematical model for use in reliability studies of an element or system.

ABSTRACT: A fundamental reliability model has been developed to guide improvements in reliability analysis techniques used in the design of new systems and the evaluation of existing systems. It provides a complete framework within which all variables influencing reliability can be included. Reliability is defined in terms of both the probabilities associated with the drift and catastrophic failure of performance attributes. The reliability model is sketched heuristically. An outline is given of a procedure for translating the theoretical model into methodology for reliability assurance. Uses of this model for reliability evaluation and improvement are cited. Initial experimental applications have been to a single-axis stabilization loop of an inertial guidance system, and to a tilt stabilization assembly for an airborne radar antenna. Additional work remains to be accomplished on translation of the theoretical model into a readily applicable engineering tool. (Authors)

REVIEW: This paper is based on the same program as the one covered by Abstract and Review Serial Number 1193. The comments on the model made in that review apply here also, of course. While a procedure is outlined for translating the theoretical model into methodology, and some uses of the model are indicated, it has not yet been translated into an engineering tool for easy application. ##

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Serial Number 1768
ASQC Code 830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Interdependence of research, design and quality control

AUTHOR: T. P. Harrington, Test and Measurement Assurance, Aerojet-General Corporation, Sacramento, California

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 219-227

PURPOSE: To point out that the manufacture of highly-reliable equipment at minimum cost calls for integrated effort from the research, design, quality control, and reliability groups.

ABSTRACT: It is suggested that successful completion of any manufacturing program depends largely upon the establishment of an early, unified effort between basic Research and Development, Design Engineering and Quality Control Organizations. In this concept, Quality Control's most important responsibility becomes that of defining potential problem areas during research, and developing techniques for their elimination prior to final design and production. While emphasis is placed on various means of achieving early resolution of these potential problem areas, it is recognized that some problems may still arise during production. However, it is shown that the background established during research and development will provide a better understanding of these production problems, thus enabling more rapid selection and implementation of sound corrective action. The overall effect is concluded to be one where quality is researched and designed into the product rather than inspected into it.

Research efforts must be sufficiently exhaustive to eliminate costly production delays. In turn, engineering must convert the research data into reliable designs whose manufacture will be controlled by meaningful specifications. The quality organization must use the knowledge gained and methods developed during research and development to insure that specification requirements and design criteria are met during production thereby minimizing expensive final product rejection. Quality control, design engineering and research cannot continue to operate as independent organizations, each unconcerned with problems of the others; instead, they must constantly strive toward integrated efforts if a highly reliable product is to be manufactured at minimum cost. (Author in part)

REVIEW: The idea that integration of all efforts affecting the final product is needed if high reliability is to be achieved will not be new to many. However, this paper serves to emphasize it. ##

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Serial Number 1769
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability and the military specification system

AUTHOR: Ralph W. Benner, Lt. Colonel, USAF, Space Systems Division, Air Force Unit Post Office, Los Angeles, California 90045

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 229-238 but see 66X81258

PURPOSE: To point out that contractors must have an understanding of the military specification and its relationship to reliability activities if contractual application is to have any effect.

ABSTRACT: Air Force reliability requirements are established contractually by MIL-R-27542A and other military specifications. Reliability program planning must result in clearly defined tasks and management methods after detailed analysis has been conducted on each of the various areas of concern. Application of the normal military specification system for part selection results in a systematic, documented approach to the part reliability task with each part traceable to an established standard or to an individually approved specification where non-standard items are required.

The content of MIL-R-27542A is summarized, and its background is described briefly. Parts technology related to the military specification system is discussed. Some extracts from applicable specifications and standards are cited. The requirements of a general piece-part reliability program are outlined, and considerations for increasing parts reliability are listed. (Author in part)

REVIEW: Those who have to deal currently with military specifications and their implementation should find this paper to be worthwhile reading. While much of the material will not be new to those with experience in the area, the considerations for increasing parts reliability should receive attention. For the newcomer to the field the paper should serve for indoctrination on the philosophy behind military specifications. It is important that contract monitors understand the reliability requirements themselves and then see that more than lip-service is paid to them. ##

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Serial Number 1770
ASQC Code 846

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Product effectiveness prediction through computer simulation

AUTHORS: Thomas J. Crowe and Irving Doshay, Product Effectiveness Division, Space-General Corporation, El Monte, California

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 245-253

PURPOSE: To describe a demonstration of a computer simulation method of predicting the inherent resistance of equipment to environmental stresses.

ABSTRACT: A methodology has been developed to predict the inherent resistance of equipment to environmental stresses. By modification of established control dynamics methods of analysis, the effects of environments on individual components can be incorporated into the analysis of an entire system. The analysis can be carried out on digital or analog computers. The methodology requires specific component test information and data. In order that the tests be the most useful, full consideration should be given to testing at a number of environmental levels. Changes in component parameters and the interactions between components may have compensating or aggravating effects on system performance. The methodology includes these changes and provides means for evaluating systems for overdesign and underdesign.

For the purposes of demonstration a fine attitude control system was considered. The mission hypothesized was for a vehicle in a circular polar orbit, passing through the outer Van Allen radiation belt, with an internal source of nuclear heat and radiation on board. The system was analyzed using transfer function techniques, with proper modification of the functions to include component parameter changes with environment. For the mission chosen, radiation and temperature were considered the significant environments. An IBM 7094 digital computer was programmed to analyze the system for various time increments during the mission.

The results of these computer simulations are evaluated in terms of cost savings, design improvement, applicability within current industrial practice, and in terms of reliability implications. Further work steps to extend and implement the methodology are considered. (Authors)

REVIEW: This paper is based on the same program as the one covered by Abstract and Review Serial Number 1237. It is concerned mainly with describing a particular demonstration of the methodology. More detail may be found in the earlier paper and also in the report cited in Review Serial Number 1237. ##

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Serial Number 1771
ASQC Codes 821;824;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Application of the Veitch Diagram to reliability analysis

AUTHORS: R. L. Montgomery and Stanford J. Axel, Reliability Assurance, Northrop Ventura, Newbury Park, California

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 255-269

PURPOSE: To describe the application of the Veitch Diagram to reliability analysis.

ABSTRACT: Reliability analysis is generally a three-step procedure as follows: (1) Formulation of a valid mathematical model--expressing as a logic equation the combination of component successes which lead to system success; (2) Boolean algebra manipulation--manipulating the logic equation for success into a form suitable for probability calculations; and (3) Calculation of system reliability--the various probabilities of component successes and failures are substituted for the logic symbols and appropriate calculations are made.

For a rather complex system, the second step can be laborious and time consuming. The Veitch Diagram, which is a flexible mathematical tool for use with logic equations, presents a method for substantially reducing the work involved; all possible expressions which are suitable for probability calculations become evident by inspection.

Brief reviews of logic, boolean algebra, the mathematical model of a system, and probability are given as background for the application of the Veitch Diagram to reliability analysis. (Authors)

REVIEW: This is a rather elementary paper which treats the topic in considerable detail, and should therefore be of use to the beginner. The method is useful in performing the simplest form of reliability analysis on relatively simple systems. The user should ensure that he understands all of the assumptions, and that they are essentially satisfied in systems to which he applies the method; for example, the behavior of each element must be such that the dichotomy into success and failure is an adequate description. ##

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Serial Number 1772
ASQC Codes 813;816

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Subcontractor reliability--a key to competitive bidding

AUTHOR: Wynn A. Gunderson, Materiel Reliability, Aero-Space Division, The Boeing Company, Seattle, Washington

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 303-313

PURPOSE: To describe a reliability program for subcontractors.

ABSTRACT: There is an increasing need for reliability program improvement on the part of subcontractors if they are to be successfully competitive in the space age. It is important to identify, primarily, those resources that already exist in the average subcontractors organization but have not been placed under formal management control. In addition the subcontractor is encouraged to develop a formal system of failure experience retention. Subcontractors who develop the reliability program described in this paper will be placing themselves in a competitive position to receive a large share of future space age contracts.

Topics discussed include management system improvement, minimizing cost, reliability resources development, experience retention, subcontractor assistance, source selection, and contracting methods. (Author in part)

REIVEW: This paper will be of interest and value to those concerned with the setting up of management systems to ensure the reliability of equipment for space applications. It will be useful also in pinpointing weaknesses in existing reliability programs. ##

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Serial Number 1773
ASQC Code 870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Maintainability for on-call systems

AUTHOR: J. L. Hochman, Lockheed Missiles & Space Company, Sunnyvale, California

SOURCE: Proceedings Eleventh Annual Western Region Conference sponsored by the Portland, Oregon Section of the American Society for Quality Control, April, 1964, pp. 357-364

PURPOSE: To describe some of the maintainability considerations and design criteria applicable to on-call missile systems.

ABSTRACT: Maintainability, the youngest discipline to become part of total quality control, has not yet been fully implemented in the design of on-call systems. Much can be gained in terms of availability of weapons for defense by design provisions for maintainability. Much also can be gained by reducing "life time" costs of weapons by timely maintainability considerations at the preliminary design stage. Quantification and demonstration of the maintainability of designs have been achieved. Coordination of the maintainability engineer, the reliability engineer and the design engineer are essential for a successful design. (Author)

REVIEW: This is a brief paper pitched at a rather elementary level on the subject of maintainability. Considerable space is devoted to defining availability, maintainability, and reliability and to indicating their obvious inter-relationships. The idea of a maintainability index is good, and a sample quantified check list for its computation is given.

The author, in a private communication, has commented as follows: "Although the relationships presented were purposely kept simple, not one of the services has recognized, through its Maintainability Specifications, that the major savings in the life-time cost of an "on-call" system are obtainable through consideration of downtime due to waiting for replacements. This is particularly true of naval vessels, satellites and even aircraft which are involved in missions for extended periods of time." He has also pointed out that the same problem is treated at a more complex level in [1].

REFERENCE: [1] Final Report, Polaris Maintainability Study, 16 July 1963, reissued 8 November 1963, prepared for Lockheed Missiles and Space Company by Sigma Corporation, 95 Main Street, Los Altos, California ##

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Serial Number 1774
ASQC Codes 833;873

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Engineers put friction to rout via new lubrication concept

AUTHOR: J. E. Sandford, Associate Editor

SOURCE: The Iron Age, vol. 193, January 23, 1964, pp. 51-53

PURPOSE: To introduce new developments in elastohydrodynamic theory and application.

ABSTRACT: The theory of hydrodynamic lubrication explains, more or less, how a lubricant behaves in a rolling bearing (and in other places as well). The classical models were not able to give adequate predictions. The elastic nature of the materials and their microscopic surface roughness were added to the model in such a way that the theory could be checked and predictions made from it. A new roller bearing is being designed by SKF, and lubricants are being evaluated better for existing bearings. The viscosity needs to be neither too high nor too low at the actual operating temperature of the film. The theory takes advantage of many new precise measuring techniques. It is expected that size and weight of bearings can be reduced for the same rating and life due to better predictability.

REVIEW: This is certainly a development in bearings that is of interest to designers. No details are given in this "popular" treatment, nor is there any indication of how widespread these developments are. For standard bearings, designers will still be interested mainly in the manufacturer's guarantees of life and load. The article perhaps gives all the insight into this work that the designer needs. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Total quality control program puts 'dent' in rework costs

AUTHOR: W. N. Redstreake, Automation Editor

SOURCE: The Iron Age, vol. 193, February 20, 1964, pp. 124-126

PURPOSE: To describe the Ford Motor Company's emphasis on perfection.

ABSTRACT: There are about 15,000 parts in a car and an average of 100 ways to do something wrong with each one. Thus there is a lot of chance for mistakes in putting a car together. Ford decided to insist on a "defect-free" program. The allowable number of sample defects was dropped to zero for all samples. The Ford policy states "Only parts, subassemblies or assemblies that fully meet all engineering specifications can be accepted for use or shipment." While there was some resistance from suppliers, most eventually fell into line and the others stopped selling to Ford. In-process inspection gages have helped to implement this policy within the plant. Workers are treated as individuals who want to do the job right and who may need help in learning how. Completed cars are randomly sampled and thoroughly checked. Mistakes are promptly referred back to the offending department or plant.

REVIEW: This is a general summary of the Ford program; few details are given. Zero defects in the sample does not, of course, imply that there are zero defects in the population. However, there are many non-statistical benefits to be gained from such insistence. One of the most basic assumptions of virtually all sampling plans is that no one has the remotest idea of the quality before a sample is taken. One of the main benefits of the insistence on zero defects in the sample is that the supplier is moved to have an excellent idea of his quality before he ships the parts.

While personal motivation is usually necessary for very high quality, it is not sufficient; programs which would not furnish adequate tools would be doomed to failure. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Putting new teeth in inspection

AUTHOR: W. N. Redstreake, Automation Editor

SOURCE: The Iron Age, vol. 193, February 27, 1964, pp. 69-76

PURPOSE: To discuss the various new in-process inspection techniques.

ABSTRACT: The increasing emphasis on high quality and high reliability is bringing 100% inspection back into the picture by means of automatic in-process inspection methods. Finding out afterwards that a finished part is no good is too late for good profits and shipping schedules. Pneumatic gaging for size is quite precise and works on dirty parts since the air blast cleans them. X rays are used to check thickness of moving strip and to detect internal flaws. X-ray emission can be used to analyze the composition of some materials. Nuclear radiation can be used in much the same way as X rays--the ranges tend to be different. Radioactive materials can be used as tracers in a great many ways; often there is no associated safety hazard. Electronic methods of presenting X-ray shadows (pictures) are much better and more sensitive than older methods; continuous observation is possible. In some cases the change in crystalline structure due to stresses can be determined by X rays. Ultrasonics is used to find flaws in materials. Novel methods of coupling the energy to the part and observing the results are being developed. Eddy current tests can determine the thickness of coatings and the size of defects. Infrared radiation can provide a measure of hot spots. These may be due to continuous operation or to transients; defects in structure can be seen in this way.

Testing is becoming more a part of in-line manufacturing and can drastically improve the quality of parts.

Several color photos illustrate the testing methods described in the text.

REVIEW: This article paints the broad picture of testing capabilities. It will best serve the purposes of those who need to know what can be done rather than how to do it. Not all the techniques are universally applicable nor are they inexpensive--many parts are just not worth checking in this way.

In-line 100% inspection by machines, especially with feedback to the process (as mentioned in the text) can be most helpful in improving product quality. In many cases the problem is not how to check, but what to check. ##

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Serial Number 1777
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: How residual stress affects fatigue

AUTHOR: (Editorial Matter)

SOURCE: The Iron Age, vol. 193, March 12, 1964, p. 139

PURPOSE: To show some advantages in shot peening.

ABSTRACT: The fatigue properties of steel are generally improved by shot peening. In hard steel there is much less effect on physical properties than there is in mild steel. Curves show the increase in fatigue limit due to compressive surface stresses for three hardnesses of SAE 86B45 steel.

REVIEW: This is a very short article. The comments on peening are well taken. For more complete information see the report covered by Abstract and Review Serial Number 435. ##

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Serial Number 1778
ASQC Codes 552;711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A method to reduce time for estimation of component life

AUTHORS: J. A. Graham, D. R. Olberts, and L. C. Wolf, Deere & Company

SOURCE: 13 pp., presented at the National Farm, Construction and Industrial Machinery Meeting, Milwaukee, Wisconsin, September 9-12, 1963, Society of Automotive Engineers paper 735B (summarized in SAE Journal, vol. 71, October, 1963, pp. 60-63)

PURPOSE: To present a short-cut method for calculating cumulative damage with a random stress history.

ABSTRACT: The conventional cumulative damage calculation assumes a linear damage theory. The fraction of failure damage incurred by any load spectrum can be "easily" calculated from the S-N curve by using this theory, although this procedure is often long and drawn-out. A simpler way is to assume that the S-N curve and the load spectrum are linear on log-log or semi-log paper. The slope of the load spectrum curve is estimated using only the few highest loads. Under these assumptions certain functions can be calculated that are universal and all one needs to know are the two slopes. These functions are tabulated in the text.

REVIEW: This short cut method is well described, but not too well justified. Under a certain few situations (in which most of the damage occurs at the high loads) it may be a reasonably good approximation, but in general the error is likely to be large. It should be noted that the load spectrum is presumed to be given in an equivalent completely reversed stress. See also the paper covered by Abstract and Review Serial Number 1733. ##

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Serial Number 1779
ASQC Codes 711;837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Predicting life of construction equipment

AUTHORS: Lee L. Lemke and James C. Tamburino, International Harvester Company

SOURCE: 8 pp., presented at the National Farm, Construction and Industrial Machinery Meeting, Milwaukee, Wisconsin, September 9-12, 1963, Society of Automotive Engineers paper 735C

PURPOSE: To outline a procedure which attempts to assure the reliability of construction equipment.

ABSTRACT: A procedure is outlined which permits the designer to use past experience in arriving at a suitable requirement for a new design.

Such factors as the following will affect life prediction:

1. Scatter inherent in all fatigue results.
2. Difficulties associated with relating random loading to fatigue data obtained from single-level loading.
3. Variability in magnitude and frequency of random loads encountered in service.
4. Manufacturing variations from expected detail.

To compensate for the difficulties mentioned above, it becomes advisable to provide an adequate factor of safety for the calculated life. Analysis of known partial or complete failure of construction equipment service parts can sometimes be valuable in determining the safety factor. This is extremely important since the accuracy of any procedure must be related to service history.

It is not feasible to design for all stresses to be below the fatigue limit (no failure due to fatigue). Therefore some damage theory must be used to calculate the expected life. Miner's linear cumulative damage theory is applied and one of the conventional formulas is used to convert actual stress "cycles" to completely reversed cycles so that the usual S-N curves can be used. Various constructional details can be compared in this way.

REVIEW: The approach described here is a reasonably practical one. The cumulative damage theory used is probably as accurate as the data and assumptions that are involved in using it. As the authors imply, engineering judgment must still be used in applying the results of these calculations. The presentation is complete enough so that an engineer with an elementary understanding of fatigue can follow it. ##

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 63A24094 Serial Number 1780
ASQC Codes 711;713

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Structural testing as related to fatigue in determining allowable static stresses

AUTHORS: Fred L. Main and Daniel C. Kloss, Euclid Division, General Motors Corporation

SOURCE: 6 pp., presented at the National Farm, Construction and Industrial Machinery Meeting, Milwaukee, Wisconsin, September 9-12, 1963, Society of Automotive Engineers paper 735D

PURPOSE: To show that static testing can be a good substitute for more traditionally accurate tests.

ABSTRACT: Although not as accurate and authentic as field durability testing or actual dynamic stress checking for structural reliability, static stress analysis is a fast and relatively thorough way of checking a design if the proper correction factors are applied and infinite life is used as the fatigue criteria in the analysis of the results. Also, to be said in favor of static analyses, is that it is ideal for the comparison of design changes because of the repeatable nature of the tests.

When the results of a test program, as outlined, are combined with actual service experience, the correction factors can be modified for future structures. Also, when structural questions persist, the "histogram" of load stresses may be obtained for a more thorough study, and again valuable information obtained for future static test programs.

Our experience in using the "weighted" stress technique has convinced us that it provides a significant improvement in the state of the art. (Authors in part)

REVIEW: The method described in this paper depends heavily on the adequacy of the method for finding the steady state mean and alternating stresses that would cause the same fatigue damage as the actual load spectrum. (No detailed justification is given.) It is this equivalent stress that is intended to be below the fatigue limit of the steel, and it is in this sense that the phrase "infinite life" should be interpreted. Not everyone agrees that these machines should be designed with equivalent stresses below the endurance limit, although this perhaps is done here in lieu of a safety factor. Just how effective this approach is cannot be determined on the basis of the evidence presented in the paper. But these "quick and dirty" methods can be very helpful in preliminary design work since they are as accurate as--or more so than--the rest of the suppositions involved in the analysis. (Several of the equations apparently contain misprints associated with the factor of 2.) ##

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Serial Number 1781
ASQC Codes 823;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Fundamentals of life testing

AUTHORS: Howard R. Roberts and Chester H. McCall, Jr., Booz-Allen Applied Research, Inc., 4815 Rugby Avenue, Bethesda, Maryland 20014

SOURCE: 8 pp., presented at the National Farm, Construction and Industrial Machinery Meeting, Milwaukee, Wisconsin, September 9-12, 1963, Society of Automotive Engineers paper 735G

PURPOSE: To present a review of some fundamental facets of life testing in reliability.

ABSTRACT: Statistics may be used for description or for inference. In life testing, inferences about the population are usually desired from the test results. If the form of a probability density function (pdf) is known, the problem usually reduces to estimating the mathematical parameters of the distribution. Three common pdf's are the normal (Gaussian), exponential, and Weibull (these are described and graphed in the text). There are non-parametric techniques for estimating the fraction of the population that lies below some particular data point. The mean (expected) rank estimate for the i th of n points is i/(n+1). There are goodness-of-fit tests to check whether or not the data could reasonably have come from an assumed distribution. The two most widely known tests are the chi-square and the Kolmogorov-Smirnov. In fitting data with a preassigned pdf, it is important to realize that the more adjustable parameters there are, the more easily the data can be fitted--regardless of any physical basis for the model.

REVIEW: This is a rather short review, but the points are well taken and clearly presented. One aspect not covered is the distinction which needs to be made between engineering and statistical adequacy for goodness-of-fit. A statistical test may well show a lack of fit (especially where there are many data), but yet the fit is more than adequate for engineering purposes.

The point concerning better fits with more adjustable parameters is especially good and often overlooked. Those who try to fit three segmental distributions to a set of data should keep it firmly in mind.

The first author, in a private communication, has commented as follows: "It is very true that a distinction needs to be made between engineering and statistical adequacy for goodness-of-fit. There are also other areas in which engineering and statistical capabilities must be combined. I feel that this can best be done by making the statistician a member of the reliability engineering team. In this way a realistic overall decision can be made with respect to such problems as the adequacy of goodness-of-fit." ##

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Serial Number 1782 -1
ASQC Codes 770;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Microelectronics reliability--where do we stand?

AUTHOR: J. D. Adams, Semiconductor-Components Division, Texas Instruments Incorporated, Dallas, Texas

SOURCE: Electrical Design News, vol. 9, September, 1964, pp. 18-24, 29

PURPOSE: To describe the reliability program for microelectronics at Texas Instruments, Inc.

ABSTRACT: The advantages including fewer interconnections, increased reliability, lower overall system cost, equal or improved performance, reduced volume and reduced weight have made the switch from discrete components to semiconductor networks seem inevitable. In preparation for this switch, quality assurance departments have set up continuing programs for reliability. The test program at Texas Instruments has been modified several times during the years of testing, but it typically covers:

Weekly samples operating at 125C;
Weekly samples on 200C storage;
Environmental testing in excess of standard MIL levels;
Operating and storage step-stress tests;
Field data review;
Continuing engineering evaluation testing.

Using these test programs as outlined, current reliability falls into three categories:

Field Data: 3,900,000 network hr; 0.025 percent/1000 hr failure rate (best estimate);
Accelerated Testing: 6,691,000 equivalent network hr at 85C;
MIL Environmental Test Level: 605 units tested show capability in excess of MIL test levels.

Reliability, as measured by failure rate, has been dramatically improving from 1961 through 1963 (1964 data are not presented). Field data are compared with laboratory tests and there is general agreement even though failure criteria for tests and field experience tend to be different and not directly comparable. The laboratory tests are all accelerated and the interpretation of the results requires careful consideration of failure modes and the physics of failure. Tests to failure, such as step-stress, are also important in finding and eliminating potential failure mechanisms.

The entire manufacturing process is monitored closely by conventional quality control techniques. Tests are made at critical points in the process for acceptance and for monitoring purposes. As a direct or indirect result of the controls, many process

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

improvements have been introduced. These control systems also act as a mechanism that assures that process changes will not have a degrading effect on ultimate reliability.

REVIEW: This is a summary of Texas Instruments' quality control and reliability effort on microelectronic devices. The description and critical discussion of the tests are good. It is perhaps unavoidable that an advertising message seems to come through although not objectionably.

There are two editorial problems: (1) on the curve for failure rate vs. calendar time there are two extraneous points, and (2) the labels on the axes of Figure 2 (failure rate vs. operating time) do not seem to make sense; apparently the horizontal label should be operating time up to one observed failure. (Actually it can be either the operating time for no failures when the number of failures is the random variable, or the operating time to the first failure when the operating time is the random variable.)

In a private communication the author has pointed out that on p. 18, column 3, under (3) the results are plotted against reciprocal of absolute temperature rather than against temperature as stated. ##

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64A22521

Serial Number 1783
ASQC Codes 300;810

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability statistical control program

AUTHORS: W. E. Sullivan and W. W. Hodge, Quality, Reliability and Standards Division, Autonetics, Division of North American Aviation, Inc.

SOURCE: 1963 Conference Proceedings, 7th National Convention on Military Electronics, sponsored by PTGMIL, IEEE, Washington, D. C., September, 1963, pp. 307-308

PURPOSE: To outline a reliability statistical control program.

ABSTRACT: A computer program has been prepared for giving quality control information on the lines most likely to have been out of control and to suppress the output on other lines. Data on failures from field and functional test reports is also fed into the computer. It is programmed to try to find correlations between the failures and the manufacturing processes. If necessary, control limits are changed for the appropriate processes.

REVIEW: This is an extremely brief paper which does little more than outline the program steps. From the information given, no judgment is possible on the adequacy of the program. ##

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Serial Number 1784
ASQC Codes 830;840;870;
880

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability aspects of military real-time command and control systems

AUTHORS: S. A. Greenberg and H. W. Williams, The MITRE Corporation

SOURCE: 1963 Conference Proceedings, 7th National Convention on Military Electronics, sponsored by PTGMIL, IEEE, Washington, D. C., September, 1963, pp. 309-312 (DDC AD No. 424953 is a reprint of this paper)

PURPOSE: To present some of the practical aspects of reliability with respect to the design of military real-time command and control systems.

ABSTRACT: Several important characteristics of a military real-time command and control system are:

1. It is unique.
2. It is evolutionary.
3. There are always new requirements and/or techniques which make past experience inadequate.
4. It is subject to yearly budget review.

Reliability (and maintainability, etc.) of systems is much more complicated and demanding than that for equipment. The interfaces create problems of compatibility, and maintenance is quite complex. Software is included in the system and one may even wish to account for "personnel reliabilities". Many self-checking, diagnostic and "repair" features can be included. The requirements for real-time operation produce additional complications. (Some of the concepts in use are briefly explained.)

REVIEW: This is a rather brief summary of the topics and there is little space for much more than an explanation of the concepts and problems involved. It gives a general rather than a detailed picture; there are no references. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability engineering review: an effective management tool

AUTHOR: W. W. DeVille, Philco Western Development Laboratories, Palo Alto, California

SOURCE: 1963 Conference Proceedings, 7th National Convention on Military Electronics, sponsored by PTGMIL, IEEE, Washington, D. C., September, 1963, pp. 313-316

PURPOSE: To present some examples of the ways in which reliability engineering review reports can aid management.

ABSTRACT: The reliability engineering review reports are calculations of the "ball-park" type using standard failure rates. They are applied at a level of complexity commensurate with the overall problem. Five examples of their use are given:

1. Reports to evaluate proposals of subcontractors;
2. Reports for project engineers on the adequacy of decisions of subcontractors;
3. Reports for project managers on the status of designs of subcontractors;
4. Reports for operation and maintenance management on the possibilities of modified redesign;
5. Reports for system management on specific subsystems.

REVIEW: The examples are illustrations of the usefulness of these "quick and dirty" calculations of reliability using tables of parts failure rates. As long as the limitations of these procedures are kept firmly in mind, they can serve a very useful purpose as shown here. ##

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64 A 22525

Serial Number 1786
ASQC Codes 824;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Satellite systems reliability

AUTHOR: Sue S. Jamison, Sperry Rand Systems Group, Sperry Gyroscope Company

SOURCE: 1963 Conference Proceedings, 7th National Convention on Military Electronics, sponsored by PTGMIL, IEEE, Washington, D. C., September, 1963, pp. 322-325

PURPOSE: To formulate a model which relates the number of satellites in orbit to the factors which determine that number.

ABSTRACT: A mathematical model for a satellite system is presented which relates the following parameters: number of satellites to be deployed in the system, mean satellite lifetime, launching reliability (reliability of lift-off and staging), number of satellites launched per payload, orbital injection reliability per satellite, and launch rate. This model is an extension of previous work in that the expected number of satellites in orbit can be estimated for the case in which there is a reduction in reliability associated with multiple-satellite-payload injection. By solving the model presented, estimates and their confidence levels can be obtained of the launching rates, number of boosters, and number of satellites required to deploy a system of satellites within a given time period and to maintain it thereafter. These results can also be used in scheduling launching facilities, satellite production, in planning for appropriate booster inventories, and in deciding on the optimum number of satellites per booster.

REVIEW: The exact nature of the assumptions which make up the model is not clear--no statements are made concerning when vehicles are launched or for what reasons. The development is rather sketchy and more information was to have been provided in the oral presentation. There are some editorial problems probably due to lack of careful proofreading. The assumptions that failure probability of satellites in orbit is constant and that the failure events are statistically independent may be restrictive, especially the latter. The independence implies (among other things) that there is only one possible environment profile for these satellites among those profiles which produce different failure probabilities. The phrase "statistically independent and uncorrelated in time" is used at least twice. The first restriction implies the second. Once the failure rate (more properly, the hazard rate) has been assumed constant, the statement "failure is considered here to be a random event not due to deteriorative causes" is unnecessary and may not even be true (see for example, theories of cumulative damage). All in all the paper will be of little use except to those directly concerned with this specific problem. ##

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Serial Number 1787
ASQC Codes 782;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability in the oceans

AUTHOR: Marvin A. Dean, Electronic Systems and Products Division, The Martin Company

SOURCE: 1963 Conference Proceedings, 7th National Convention on Military Electronics, sponsored by PTGMIL, IEEE, Washington, D. C., September, 1963, pp. 326-328

This paper is very similar to the one by the same author covered by Abstract and Review Serial Number 1677. ##

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Serial Number 1788
ASQC Code 817

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

TITLE: Economic balance in reliability objectives

AUTHOR: G. L. Hetzel, Bell Telephone Laboratories, Inc., Whippany, New Jersey

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 1-2--1-8

PURPOSE: To point out the trade-offs that must be made for minimum system total cost.

ABSTRACT: For reliability objectives to be fully meaningful in the development of a system which will efficiently achieve its intended function, consideration of total system cost in the formulation of these objectives is necessary. The relationships between system characteristics, such as performance, reliability, maintainability, etc., have to be estimated utilizing past experience and existing preliminary system information. Trade-offs between these characteristics are then evaluated to arrive at a system developmental and operational plan which realizes the system's intended function at minimal total cost. Total cost includes all costs from inception of the system concept to its operation and maintenance by the user throughout its service life. Such an integrated analysis should be part of the system feasibility study. (A very simple example is given.) (Author in part)

REVIEW: This is a rather general paper. The concepts expressed are important and need to be considered in the design of systems. The cost functions are generally most difficult to come by. In the analysis of any model, one should be careful about blindly searching for minima and maxima. For example, in the illustrations in the paper the minima are quite broad and hence the costs are relatively insensitive to the exact parameters chosen in the region of the minimum. Other factors, not included in the model, might well suggest a departure from the nominally optimum value.
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R E L I A B I L I T Y A B S T R A C T S
A N D T E C H N I C A L R E V I E W S

TITLE: Economics of implementing reliability objectives

AUTHOR: George H. Ebel, Du Mont Laboratories, Division of Fairchild Camera and Instrument Corporation, Clifton, New Jersey

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 2-2--2-11

PURPOSE: To describe the reliability program and its justification at the Du Mont Laboratories of Fairchild.

ABSTRACT: An effective reliability program must be able to justify itself by saving money for the project. As a rule of thumb, it need not cost more than 5% of the total project budget. Severe problems that arise can be funded separately. The reliability effort should not be directed toward doing what other departments are doing poorly; rather, those poor departments should be stimulated directly. A sound reliability group should have close ties to design and a direct line to top management. It should possess the requisite reliability knowledge. A description is given of the Fairchild reliability group which is small, well-integrated and effective. It is made up largely of design engineers who are borrowed from engineering on a rotating basis. This gives them valuable training.

The use of digital computers is frequently hailed as a reliability analysis must. In many cases, and at Fairchild, it is; but the decision should be based on the relative costs of computation. After all, the computer does only what it is programmed to do. It can be used to calculate many routine statistical quantities, to predict spare parts needs from reliability and other data, and to simulate parts of a system. A failure report-and-analysis system is vital--especially the analysis part, without which the first is a waste of time. There must be follow-up to see that the cause of failure is eliminated if possible.

Several examples are given of the benefit of such a reliability program.

REVIEW: This is another of the papers describing the whys and wherefores of a specific reliability program. Much of the emphasis appears to be good--such as giving design engineers experience with reliability problems. Some points are controversial--such as pinpointing personal responsibility for a failure. The paper will be of most help to those involved in or responsible for reliability programs. ##

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Serial Number 1790 -1
ASQC Codes 814;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Application of cost and effectiveness analysis methods to aeronautical systems

AUTHOR: William H. von Alven, ARINC Research Corporation, Washington, D. C.

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 3-2--3-14

PURPOSE: To describe some cost and effectiveness models for systems.

ABSTRACT: System worth is a function of system cost, effectiveness, scheduling and personnel requirements. Models for cost and effectiveness are given in this paper. Effectiveness is reliability x operational readiness x design adequacy (all terms are defined as probabilities or conditional probabilities). In cases where various modes of operation are possible, the components of effectiveness can be expressed as matrices in such a way that the product is a scalar. Cost models should provide information with regard to: complete costs of present support of units; support costs as a function of reliability and maintainability; at which echelon repairs are cheapest; capital costs vs. labor costs; etc. The result should be a model from which changes can be evaluated. An example of a cost model and a few general references to books are given.

REVIEW: This is a rather general paper which gives an insight into what can and ought to be accomplished by cost and effectiveness models.

In the discussion of simple models, four events are introduced along with their probabilities. These events are:

SE ≡ the <u>s</u>ystem is <u>e</u>ffective,
MR ≡ the system is <u>r</u>eliable during the <u>m</u>ission,
OR ≡ the system is <u>o</u>perationally <u>r</u>eady, and
DA ≡ the <u>d</u>esign is <u>a</u>dequate.

Each of the events is then described in some detail. The probability of each is denoted by P with a subscript designating the event. A problem arises from Equation (1) of the text which asserts that

$$P_{SE} = P_{MR} \times P_{OR} \times P_{DA}.$$

This implies that the event SE is the joint occurrence of the three events MR, OR, and DA and that these events are statistically independent. It is not at all obvious that the events are statistically independent and the equation should be written (using parentheses instead of subscripts to denote the events):

$$P(SE) = P(DA)\ P(OR|DA)\ P(MR|OR \text{ and } DA);$$

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

but the event MR implies OR, therefore

$$P(SE) = P(DA)\ P(OR|DA)\ P(MR|DA).$$

The concept of DA is best employed when failures are catastrophic rather than due to drift, and when the dichotomy of success and failure is quite appropriate. Under other circumstances the events MR and DA are related and not easy to define.

The matrix model in the paper gets away from some of these problems, since it is more comprehensive. Nevertheless, the habit of blithely using multiplied probabilities to indicate some not-well-defined concepts should be avoided. (The example in the text--discussed above--is handled better than many others that appear in the literature.) ##

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Serial Number 1791
ASQC Codes 813;844;851

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Establishment of a microelectronics reliability testing program

AUTHOR: Earl P. Reed, Sylvania Electronic Systems, A Division of Sylvania Electric Products Inc., Waltham, Massachusetts

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 5-2--5-10

PURPOSE: To report on the Sylvania thin-film microcircuit testing program.

ABSTRACT: The testing of devices at normal operating conditions for estimating reliability takes too much time and money if the devices have a long life. Sylvania is using accelerated tests, characteristics' measurements, and failure mode analysis to estimate and improve the life and behavior of their thin-film microcircuits. These circuits use fired silver conductors, evaporated nichrome resistors, titanate chip capacitors and special diodes and transistors. A typical wafer is 1 inch square by 0.15 inch thick. Accelerated tests on resistor patterns are run at 75, 100, 125^{o}C and 10, 20, 40, 60 watt/in^{2} (of actual resistor area). Some digital circuits have been put on tests and performance measures such as pulse rise time are monitored. The results to date indicate that the microcircuits will at least meet most of the original goals.

REVIEW: This appears to be an adequate program based on engineering experience and held to a reasonable effort. Naturally, such programs do not give all the answers and assurance which one would like to have, but the essence of good engineering is to make the best of what one has. (No estimated life figures were available for the microcircuits.) ##

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Serial Number 1792
ASQC Codes 771;813;835;
844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Application reliability of micromodule

AUTHOR: Donald T. Levy, Radio Corporation of America

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 6-2--6-18

PURPOSE: To give a progress report on the RCA micromodule program.

ABSTRACT: This paper is an updated version of the papers covered by Abstracts and Reviews Serial Numbers 110 and 734. Over 10^8 element-hours of testing have been completed. Modules have been exposed to ultra-high shock impact, to 5×10^{14} neutrons/cm^2 and other severe environments. During 1962 an MTBF of 468,000 hours was achieved for a ten-element digital module (60% confidence and 85°C hot-spot for germanium devices, 110°C for silicon devices). The Signal Corps requirement was only 1/6 the achieved value. The results show that micromodule reliability is competitive with all other high reliability efforts.

REVIEW: This is a good progress report on the program and the results look good compared to those for conventional components. No 1963 results were given and no comparisons are available with silicon integrated devices which have become quite popular since this report was presented and which may well have greater potential in many areas. It is quite likely that the micromodules will fade into obscurity due to the popularity of micro-integrated devices of several kinds. ##

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Serial Number 1793
ASQC Codes 431;831;838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Dynamic reliability instantaneous forecasting technique

AUTHOR: N. Jagodzinski, Sylvania Electronic Systems, a division of Sylvania Electric Products Inc., Williamsville 21, New York

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 7-2--7-16

PURPOSE: To show the application of Markov chains and the transition matrices to the estimation of mission reliability.

ABSTRACT: The theory of Markov chains is applied to the calculation of reliability of systems containing redundancy. The states of the system are the various combinations of success and failure of the several elements. The probability of successfully completing the mission can be calculated at any point during the mission (assuming that the mission is broken up into a finite number of intervals). Various simplifying assumptions are made for the examples.

REVIEW: The paper is fairly easy to understand and appears to present the material well. It is for the beginner in this field. The example involving a transmitter is rather abbreviated (probably due to editorial limitations) and consequently is somewhat difficult to understand fully. When applying such a model as this to an actual problem, it is wise to state the various assumptions that are being made to see if they are realistic. For example, it is not clear whether this model is applicable in a situation with several possible environmental profiles or where cumulative damage is present. ##

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Serial Number 1794
ASQC Code 838

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

TITLE: Calculation of circuit reliability by use of von Neumann redundancy logic analysis

AUTHOR: N. T. Grisamore, Center for Measurement Science, The George Washington University, Washington, D. C.

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 8-3--8-9

PURPOSE: To show how to make computations of reliability when using majority logic.

ABSTRACT: The application of majority logic to increase the reliability of digital systems is treated in detail in order to aid designers in taking advantage of this method. Consideration of the effects of failure modes on probability of failure is explained at some length. A short review of the concept of majority logic is included to familiarize the reader with von Neumann's idea and it is compared with the Moore-Shannon relay network reliability. (Author in part)

REVIEW: This analysis covers many important cases. It is more valuable than some others because it considers not only success/failure but also the ways in which the device may fail. The latter analysis is much more applicable to majority voting circuits than the simple binary analysis. (The paragraph comparing MTBF with MTF, and catastrophic vs. random failures is not at all clear. Ignoring that paragraph, it is a reasonably adequate procedure and the remainder is clear enough by itself.)

The author, in a private communication, has pointed out that there is an error on p. 8-9 in the paper. The expression for the series-parallel case should read as follows:

$abcd + abc\bar{d} + ab\bar{c}d + ab\bar{c}\bar{d} + \bar{a}bcd + a\bar{b}cd + \bar{a}\bar{b}cd$. ##

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Serial Number 1795
ASQC Codes 720;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability: The design-production interface

AUTHOR: E. F. Dertinger, Raytheon Company, Equipment Division

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 10-2--10-6

PURPOSE: To point out that design, production, and quality assurance must be well integrated in order to achieve quality products.

ABSTRACT: We know more about how to design and produce reliable products than we are able to put into practice. Constraints on time and money and mismatch between Design and Production result in our not applying all the reliability and quality control techniques we know about during the design phase in order to optimize the achievement of reliability during production.

Suggestions are made as to how to apply reliability and quality control techniques in parallel with design effort, in such a way that achievement of reliability objectives is enhanced without impediment to the design schedule. (Author in part)

REVIEW: This paper is printed as an extended abstract only.

The ideas of removing barriers between the disciplines and making the best use of available time and money are very worthwhile.

The concept that manufacturing and use are degrading activities is not a very useful one. Rather, everyone in the product cycle contributes to the product in some way. To imply by omission that the designer does not contribute his share to poor performance is to overestimate his ability. The expressing of overall reliability as the product of three reliabilities (inherent design, manufacturing, and use) is to both misunderstand the nature of conditional probabilities (see Review Serial Number 1790) and to use a poor concept as mentioned above. In a private communication the author has pointed out that the oral presentation gave more emphasis to the fact that reliability and quality control personnel must learn to live with the rest of the production complex and must actively learn and practice the real meaning of engineering trade-offs. ##

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Serial Number 1796
ASQC Codes 810;841;846

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Obtaining and using data--basic objectives in reliability management

AUTHORS: C. C. Tyler, Jr. and C. O. Wright, Western Electric Company, Inc., Winston-Salem, North Carolina

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 11-2--11-9

PURPOSE: To outline the conventional evolution of a product to show the interdependence of management and engineering in obtaining reliability data.

ABSTRACT: The phases through which a product evolves are design, model, prototype, production, and use. Each of these phases represents a source area, or input, of reliability information. The selected example of a specific source (prototype-production evaluation testing) is but one of several significant technical functions that pertain to generating and using reliability information. Others could have been discussed similarly in terms of the interrelationship between technical functions and the associated management tasks. The specific developments become part of a build-up of reliability information that eventually provides the producer with confidence in his final decision to go into production.

We have deliberately concentrated our viewpoint on a basic reliability objective. This basic objective of obtaining and using data is one which makes possible the attainment of the broader objectives of an over-all reliability program. In considering the technical functions that must be applied in connection with reliability information, it is recognized that technical competence in itself will not ensure satisfactory attainment of the basic objectives; similarly, neither will management competence alone. Reviewing some of the detailed considerations in obtaining and using reliability information emphasizes the strong interdependence between fundamental management tasks and technical operations. (Authors in part)

REVIEW: This paper makes several good points about data for use in product evaluation. In general the discussion is without regard to the limitations under which many projects are carried out. The emphasis on planning and integration of tests is good, but sometimes time and money are not available for the full planning and execution. In a private communication the first author has stated that he hoped that the paper did convey the fact that a too limited project negates execution of even the basic reliability objective of using factual data. Without it, the manufacturer is relying on inherent know-how. ##

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2/65

Serial Number 1797
ASQC Code 814

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Can reliability survive the hazards of cost reduction?

AUTHOR: Marvin Kaplan, Loral Electronics Corporation, Bronx 72, New York

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 12-2--12-6

PURPOSE: To illustrate the point that reliability and value engineering are not only compatible, but can help each other.

ABSTRACT: This paper deals with reliability-oriented techniques which must be considered when implementing value engineering in a product or design. In the same manner that cost reduction can be accomplished without degrading quality, so can value engineering be utilized without affecting specified reliability parameters. Examples are included to illustrate how reliability can be degraded or maintained by proper value engineering applications. (Author)

REVIEW: This paper shows that value engineering is good engineering and that reliability engineering is good engineering, so that obviously the two are part and parcel of the same overall goals: to produce the optimum product. The points are well taken and the examples are interesting. Unfortunately, not all value engineers or reliability engineers are good engineers; this gives rise to the severe problem and the bad names each discipline gets.
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Serial Number 1798
ASQC Codes 770;835;844

431;838;872;
882

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Application reliability of integrated semiconductor networks

AUTHOR: P. F. Buckler, Quality and Reliability Assurance Department, Texas Instruments Incorporated, Semiconductor Components Division

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 4-2--4-21

This is a description of the program of Texas Instruments, Incorporated for silicon integrated circuits. As such it is a somewhat more complete but older paper than the one covered by Abstract and Review Serial Number 1782, which deals with the same program.

TITLE: The MTBF and availability of compound redundant systems

AUTHOR: Ronald S. Dick, International Electric Corporation, Paramus, New Jersey

SOURCE: Proceedings Fourth Annual New York Conference on Electronic Reliability sponsored by IEEE, Metropolitan New York Chapters PTGR, PTGCP, and PTGPEP, October, 1963, pp. 9-2--9-5

This paper deals with the problem of determining MTBF and availability for systems which have both working and non-working states. It is essentially a summary of the papers by the same author covered by Abstracts and Reviews Serial Numbers 504 and 896. The introduction is rather abbreviated, which makes the paper rather difficult for the non-expert to follow. ##

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Serial Number 1799
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability through a system of standards

AUTHOR: Philip A. Thompson, Minuteman Division, Melpar, Inc.

SOURCE: Proceedings Twelfth Annual Meeting, Standards Engineers Society Incorporated (170 Livingston Avenue, New Providence, New Jersey 07974), Washington, D. C., September, 1963, pp. 27-38

PURPOSE: To show the types of specifications used by the Minuteman Division of Melpar, Inc.

ABSTRACT: It is apparent that each phase of a program, from the research-engineering design effort on through the fabrication and manufacturing stages, must share a responsibility for ultimate system reliability. It has been a difficult task in the electronics industry, with its rapidly changing technology, applications, and ever-increasing miniaturization, to develop and keep pace with adequate standards and processes.

Although many other facets in the manufacture of Minuteman electronic equipment contribute to overall reliability, standardization plays a particularly important role in the following areas:

- Vendor Control
- Receiving Inspection and Component Test
- Fabrication and Assembly
- Data Analysis
- Receiving Component Test
- Final Functional Test

The role of standards in each of these areas is described briefly. (Author in part)

REVIEW: This is more a discussion of specifications than of standards insofar as the two words have different meanings. Some standardized methods are briefly described.

The paper is of more interest to management than to design engineers. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Air Force maintenance and maintainability programs

AUTHOR: Brigadier General Lawrence F. Loesch, USAF Headquarters

SOURCE: Proceedings Twelfth Annual Meeting, Standards Engineers Society Incorporated (170 Livingston Avenue, New Providence, New Jersey 07974), Washington, D. C., September, 1963, pp. 57-59

PURPOSE: To give an overall view of Air Force maintenance policy.

ABSTRACT: The maintenance of our forces is a tremendously expensive effort. Actually, the task of keeping aircraft and missiles in commission is the largest single function of the Air Force. In Fiscal Year 1963, maintenance work accounted for nearly one-third of the Air Force's budget of approximately 20 billion dollars. Standardizing the best concepts, best policies, and best procedures for Air Force-wide application resulted in Air Force Manual 66-1 entitled Depot, Field and Organizational Maintenance Managment.

We decided that our first and possibly our most important task was to develop a standard organizational structure that would function equally well in our strategic, tactical, airlift, defensive and support operations. Wherever you go in the Air Force you will now find the same organizational structure in use by maintenance engineering functions at base level.

The objective of our maintenance data collection system is to furnish each base chief of maintenance with facts that allow him to manage his organization in a professional manner. But the data utilization does not terminate at base level. The world-wide data are brought into a computer center at Wright-Patterson AFB. One of many fine examples of the results of the various analyses of these data concerns the B-52G aircraft. We found that during each periodic inspection, mechanics were checking 2,000 items that were consistently found to be in proper operating condition. These items were eliminated from subsequent inspections. This action reduced the inspection time from 255 manhours to 25.

Inasmuch as our weapons are becoming more complex, it is obvious that the surest way to hold the line, or reduce Air Force maintenance costs is to ease the accomplishment of maintenance. This can be accomplished on the drawing table by designing for maintainability. Maintainability, then, is an important word in the Air Force vocabulary. (Author in part)

REVIEW: Although quite brief, this paper paints an overall picture of Air Force maintenance policy. The application of standards to maintainability problems while the equipment is still in design and development would be expected to return large dividends. ##

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Serial Number 1801 -1
ASQC Codes 815;845

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Part reliability aspects of NASA space programs

AUTHOR: Wayne Wagnon, George C. Marshall Space Flight Center, Huntsville, Alabama

SOURCE: Proceedings Twelfth Annual Meeting, Standards Engineers Society Incorporated (170 Livingston Avenue, New Providence, New Jersey 07974), Washington, D. C., September, 1963, pp. 96-100

PURPOSE: To describe some of the approaches and programs for parts reliability at the Marshall Space Flight Center.

ABSTRACT: The National Aeronautics and Space Administration is committed to a program of extending the realm of manned space flight competence to a quarter-million miles from the earth. Reliability growth experience indicates that some 30 to 40 flights are necessary to achieve a system's potential reliability. Because of cost and time considerations, the characteristic reliability growth of Apollo must be drawn from the first few flights. The first step taken was the initiation of an inventory of all parts used in the Saturn vehicle. This information defines the basic problem and provides a background for a meaningful program. A study of the parts inventory revealed the use of many obsolete parts. Attention is called to those parts currently used that have exhibited high failure rates and poor application experience. The file of technical information that has been developed at the Marshall Space Flight Center is known as the Parts Reliability INformation CEnter. The objective of PRINCE is to gather and make available in a usable form all the technical information that can be useful in a parts program. PRINCE accepts data in any format with standardization accomplished within the system. Maximum use has been made of the existing nationwide parts data centers such as IDEP and ECRC. By making a request by mail, teletypewriter, personal contact, or telephone, a design engineer or parts specialist can inquire and obtain from PRINCE all of the available information concerning a particular part. There are two search methods: (1) An alpha-numeric index search and (2) an abstract search. The second includes the first with the addition of hard copy for backup documents. If the designer chooses, he may register a request for information as it becomes available on any part; this will be furnished as new data are added to PRINCE through an automatic printout.

A preferred parts list is also published for inhouse and contractor use. Specifications for these parts are necessary and are of three types: product evaluation, military, and screening. A fourth type to be added is the high reliability or established reliability specification. The screening specification has been accepted as the "work horse" at the Marshall Space Flight Center. Usually,

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

it consists of the basic military specification with additional requirements imposed both on the parts and on the vendor. The screening specification may also change allowable parameter variations stated in the military specification. It specifies stringent quality and reliability assurance requirements based on the NASA NPC publications.

High reliability specifications are designed to be complete, independent documents used for the purchase and testing of parts. They must at least meet the following major stipulations:

1. All special test and measuring equipment, special setups, and environmental test methods used in part testing must be adequately described.
2. Relative to each test method, the specification includes inspection levels, showing end-point limits and the number of failures allowed, to assure maintenance of the stipulated reliability index.
3. Each specification includes life test requirements. The allowable number of failures from a stated size lot is specified, together with the allowable minimum quantity to be tested.
4. Each specification requires a definite number of hours or cycles of functional operation of all units to detect any changes in the product and to cull out early failures (burn-in tests).
5. Each specification imposes requirements on vendor management to maintain a high-level quality control over production and to monitor design, process, or test changes to assure uniform quality.
6. Each specification requires that vendor records showing performance of the part or failures in daily lot-sampling tests be available for review.
7. Individual part markings are required to completely identify each part, lot, date, and manufacturer.

The program plan stipulates requalification of all parts procured under screening specifications once each year. To prevent requalification with each purchase, it is planned to request bids for a one year's supply. The reliability of parts in general must progress to higher levels if the mission goals are to be satisfied. The MSFC program has proved to be a logical approach in stimulating the development and use of parts with increased reliability. (Author in part)

REVIEW: This paper is more about specifications than standards insofar as there is a difference. Presumably many of the Hi-Rel specifications will be standardized where possible. For those doing business with NASA, this paper can furnish insight into some of their intended ways of doing business. ##

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Serial Number 1802
ASQC Codes 833;845

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Integrating the design selection of component parts

AUTHOR: Jack A. Sellers, Jr., Technical Information Systems and Service, Inc., 1430 West Peachtree Street, N. W., Atlanta 9, Georgia

SOURCE: Proceedings Twelfth Annual Meeting, Standards Engineers Society Incorporated (170 Livingston Avenue, New Providence, New Jersey 07974), Washington, D. C., September, 1963, pp. 101-105

PURPOSE: To describe the service of Technical Information Systems and Service, Inc. in providing information on components.

ABSTRACT: Technical Information Systems and Service, Inc. has spent three years accumulating, classifying, sorting, and indexing files on relays, resistors, switches, connectors, and capacitors. A component information service is now available. This is a user's service and is tailored to user requirements. Under a Lockheed-Georgia contract the procedures for its use are: An engineer jots down in any order the system or performance requirements of an item--say a relay. On the basis of these requirements Technical Information Systems and Service makes a search of its files. From these files is printed out a list of suppliers who produce a standard item conforming to the user's requirements. For each supplier a specifications sheet is provided on which are shown the full range of characteristics that appear in the files.

Pertinent, current, complete data is the base for making valid decisions. Technical Information Systems and Service has produced a system to accumulate, classify, sort, store, and disseminate component data and can provide engineering with a preselected list of components screened to the engineer's requirements from a complete file. (Author in part)

REVIEW: The service described here would appear to be quite useful to designers, and many will want to investigate it further. Its utility is difficult to evaluate from this article partly because there is little concrete information and partly because it needs to be tried before a sound judgment can be made. As pointed out in the paper, no attempt is made to evaluate the accuracy of vendor data.

The author, in a private communication, has pointed out that evidence of the utility of the service exists although it was not given in the speech, and that his company is at present supplying NASA with data. In regard to vendor data he has commented as follows: "... we do include test report identification on items. We have found that vendors know more about their items than does anyone else and their data is accurate under the conditions of their test." ##

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Serial Number 1803
ASQC Codes 714;716

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Corrosion control by materials selection

AUTHOR: Carl H. Samans, Assistant Director, Engineering and Materials Research, American Oil Company, Whiting, Indiana

SOURCE: Metal Progress, vol. 84, September, 1963, pp. 74-78

PURPOSE: To point out ways of improving the efficiency of present materials in corrosive media.

ABSTRACT: In the absence of government specifications or product purity requirements, economics are the primary factors which control material selection in the process industry. Furthermore, since capital costs can be expected to outweigh maintenance costs, carbon steels are usually selected. Cost factors, relative to carbon steels, are listed for various structural materials. The use of linings--loose liners, welded liners, and bonded liners--for corrosion resistance of carbon steel structures is discussed. The corrosion resistance of alloys, castings, and weldments can be enhanced by control of microstructure. Better corrosion resistance can be expected from improved homogeneity resulting from homogenizing heat treatment, sometimes preceded by cold work, of nonhomogeneous materials. Both general and specific case histories are presented.

REVIEW: This is an interesting semi-technical article which is rather general in nature. It should be valuable to the young design engineer. The techniques discussed in the paper for improving corrosion resistance are applicable, with modifications, to any industry. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Closing the metal gap (looking to 1980)

AUTHORS: Walter L. Finlay, Crucible Steel Company of America, Pittsburgh Pennsylvania and Joseph R. Lane, Materials Advisory Board, National Academy of Sciences - National Research Council

SOURCE: Metal Progress, vol. 84, September, 1963, pp. 79-84, 120, 122

PURPOSE: To present a general review of the future strength requirements for structural materials.

ABSTRACT: The metal gap is the difference between the theoretical maximum strength and the attained strength of metals. The ideal breaking strength of metallic materials by pure cleavage is approximated as 10% of the modulus of elasticity in tension. The theoretical maximum shear stress is approximately G/10 to G/30, where G is the shear modulus. Since the axial shear stress is at least twice the resolved shear stresses, the maximum theoretical flow stresses are G/5 to G/15.

Metal gap charts with forecasts and goals for various materials are illustrated. General recommendations for research to bridge the metal gap are: (1) basic and applied research on the micromechanisms of metal strengthening and fracture, (2) alloy development and associated processes to take advantage of the new micromechanism knowledge, and (3) corrosion and oxidation protection against the time-temperature atmosphere conditions made possible by higher strengths. Specific approaches to span the 1980 gap are indicated, along with the probable and possible chances of success, for Al; Mg; Be; Ti; Cb; Mo; W; super alloys; stainless steel; and nonstainless steels.

REVIEW: This paper is a general summary of Report MAB-187-M, Vol. 2, Department of Defense Program on Materials Research and Development, Committee 2 on Metallic Materials (1961-1962). Although interesting, the paper is of general nature and of little value as a reference for the design engineer or the researcher. An example of yield strength at a specific temperature is given for eleven metal systems, but the data are probably available elsewhere. Certain general and specific examples of metallurgical research which might receive government sponsorship are listed. ##

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Serial Number 1805
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: New methods of evaluating lubricants based on the surface energy/hardness ratio

AUTHORS: E. Rabinowicz and R. G. Foster, Massachusetts Institute of Technology

SOURCE: 5 pp., presented at the National Fuels and Lubricants Meeting, Tulsa, Oklahoma, October 30-31, 1963, Society of Automotive Engineers paper 776A

PURPOSE: To develop and present a theoretical framework for the correlation between the surface energy/hardness ratio and the performance of materials under lubricated sliding conditions.

ABSTRACT: An important new parameter, surface energy/hardness ratio (W/p), for evaluating the performance of a pair of contacting materials and sliding conditions is described. W is the energy of adhesion for the contacting surfaces, and p is the penetration hardness of the softer material. The coefficients of friction and size of wear particles generated for clean unlubricated sliding metal combinations, stable in air, increase linearly with the W/p ratio. Peak-to-peak roughness of the sliding surfaces is of the same magnitude as the wear particle size and, therefore, related to the W/p ratio. Low wear is associated with low W/p ratios; and severe surface damage, galling, and high wear are related to high W/p ratios. The concept of wear particle size and equilibrium surface roughness establish practical limits for the design of surface finishes and clearances for sliding systems.

REVIEW: This paper is a valuable contribution to the literature. The authors have analyzed the characteristics of sliding systems and have thoroughly developed their experimentation based on the analysis. They have explained deviations from expected performance with reasoning and statistical models. Adequate descriptions of the test apparatus and experimental procedure, with modifications, are included. ##

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64A13708

Serial Number 1806
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Fatigue behavior of high-carbon high-hardness steels

AUTHOR: Robert F. Thomson, Technical Director - Engineering Research, General Motors Corporation, Research Laboratories

SOURCE: *Transactions of the ASM*, vol. 56, 1963, pp. 803-833 (Campbell Memorial Lecture for 1963)

PURPOSE: To review and summarize the present state of knowledge of, and to present new data on, the fatigue behavior of high-carbon high-hardness steels.

ABSTRACT: Variability of fatigue life for high-hardness material (Rockwell C60) may be greater than 1000 to 1; and, above Rockwell C40, the fatigue endurance limit does not correlate with tensile strength. Plastic flow was observed in high-hardness material, but extensive slip does not appear to precede final failure under cyclic stressing. Unlike soft materials, hard materials do not fatigue over an appreciable time period. In high-hardness material, the rate of crack growth from the time the crack becomes detectable until complete failure occurs is very rapid. The crack size for propagation in the high-hardness material is extremely small; but, once the crack is formed, its velocity of propagation is extremely fast. Weibull correlations indicate there is a multiple distribution of failures in the harder materials. Water vapor, deleterious refractory inclusions, and other crack nucleating agents are the most important contributors to fatigue failure in hard materials. Sulfide inclusions are less objectionable than the more refractory inclusions. Temperature (70 to 250F), material composition, heat treating, and retained austenite variations were overshadowed by heat-to-heat and inclusion characteristics. The fatigue behavior of hard steels (over Rockwell C50) is different from that of soft steels, but the mechanism of failure for both hard and soft steels is the same.

REVIEW: The author includes a review of the fatigue process for soft materials, and then compares the fatigue behaviors of hard and soft steels. Since a definite endurance limit cannot be determined for high-hardness material, the author points out that an analysis based on a statistical approach is the most logical. Certain cautions should be exercised when extrapolation of data obtained by statistical analysis is contemplated.

The paper is well organized, clearly presented, and easy to understand. The conclusions are reasonable and substantiated with experimental data and reasoning. It should be of use to designers. The author's recommendations and suggestions for future study are included. ##

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65X84790

Serial Number 1807
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Some remarks on a theory of creep-rupture of pressure vessels

AUTHOR: G. R. Cowper, National Aeronautical Establishment, National Research Council of Canada, Ottawa, Canada

SOURCE: Aeronautical Report LR-370, 27 pp., National Research Council of Canada, January, 1963 (DDC AD No. 403089)

PURPOSE: To present a more usable form of the Rimrott, Mills, and Marin theory of creep-rupture for thick-walled cylindrical pressure vessels.

ABSTRACT: The Rimrott, Mills, and Marin theory of creep-rupture for thick-walled cylindrical pressure vessels is modified by defining a fictitious effective stress in the cylinder. The effective stress is such that a rod of the same material subjected to the stress would rupture in the same time as the cylinder, i.e. the effective stress is directly compared to the rupture strength of the material. The development of the theory for the following two special cases is included: (1) thin-walled cylinders, and (2) ideally plastic materials. Further modification of the theory is accomplished by using Tresca's flow rule, instead of Von Mises', in order to account for deviations between theoretical and experimental results. The modifications give good results in some cases; but, in other cases, the results are poor. Generally, the modified theory underestimates the effective stress, particularly at long rupture times, which gives results on the unsafe side.

REVIEW: The paper is nearly self contained since it includes: (1) a summary of the theory being modified, (2) evaluation of difficult integral functions, (3) derivations of complex formulae, (4) listing of certain coefficients, and (5) the development of two special cases. Comparisons of the modified theory with experimental data are included for 316 and 321 stainless steel, carbon steel (SA-210), and 2 1/4-Cr 1-Mo steel. The paper is a good contribution to the literature, and it should be valuable as a reference to both the researcher and the design engineer. ##

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Serial Number 1808
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The fatigue crack propagation characteristics of titanium and two titanium alloys

AUTHORS: N. E. Frost and K. Denton, Department of Scientific and Industrial Research, National Engineering Laboratory, East Kilbride, Glasgow, Scotland

SOURCE: NEL Report No. 76, 38 pp., Department of Scientific and Industrial Research, National Engineering Laboratory, East Kilbride, Glasgow, February, 1963 (DDC AD No. 406989) See also 65A10294

PURPOSE: To present results of fatigue crack growth tests for sheet specimens from commercially pure titanium and two titanium alloys.

ABSTRACT: Fatigue tests of center slit specimens (10 in. wide by 1/8 in. thick) of titanium 130 (commercially pure Ti), titanium alloy 317 (5% Al-Ti alloy), and titanium alloy EX011 or 205 (15% Mo-Ti alloy) were completed. Tensile properties of the three materials were determined. Crack half-lengths were measured at frequent intervals throughout the fatigue tests. Crack growth planes for titanium 130 and titanium alloy 317 differed from the crack growth planes for titanium alloy EX011. Titanium 130 demonstrated ductile failure, but both the 317 and EX011 titanium alloys failed in a brittle manner. The three materials demonstrated similar crack propagation characteristics; however, the rate of crack growth was somewhat slower in the 5% Al-Ti alloy. For similar loading conditions, a crack will grow at least nine times faster in the titanium alloys than in mild steel. At 15 tons/in.^{2}, a crack will grow at least nine times faster in aluminum alloy B. S. L71 (4½% copper) than in the titanium alloys.

REVIEW: The authors have analyzed the results of tests similar to those in previous work published by one of the authors. The tests were carried out over a sufficiently large load range, with four replications at each load. Interpretation of the results appears to be adequate and sound; numerous tables and graphs illustrate them. The paper should be of value to design engineers in the titanium field. ##

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Serial Number 1809
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The 'usable' strength of metals

AUTHOR: Joseph D. Morrison, Research Metallurgist, Southern Research Institute, Birmingham, Alabama

SOURCE: Bulletin of Southern Research Institute, vol. 15, Winter, 1962, pp. 12-17

PURPOSE: To review metal strength and strengthening mechanisms.

ABSTRACT: The strength/density ratio of metals is discussed along with reasoning for non-attainment of theoretical metal strength goals. The toughness concept of strength is included, and usable strength is defined as the combination of the properties of high tensile strength and good toughness. Three strengthening mechanisms, with examples, are presented:

1. Transformation strengthening - Phase transformation of the matrix metal.
2. Precipitation hardening - finely dispersed precipitate forms within the matrix metal.
3. Work hardening - crystals or grains become elongated and develop resistance to additional deformation. Certain metals undergo strain-induced transformations with cold work.

Dislocations and their effects on metal strength are explained. Combinations of the three strengthening mechanisms are presented to illustrate the potential for improved metal properties.

REVIEW: This is a semi-technical paper presenting general information concerning strength and strengthening mechanisms of metals, but it is not for reference. It would be useful for orientation of the uninformed or partially informed, particularly beginning materials engineers. (A paper in the same vein was covered by Abstract and Review Serial Number 1804.) ##

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65N81082

Serial Number 1810
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Fatigue of metals--Aluminum--Section III

AUTHORS: Technical Information Systems Division of Belfour Engineering Company, Suttons Bay, Michigan

SOURCE: ASD Technical Note 61-117, Part V, 26 pp., May, 1963, Application Laboratory, Directorate of Materials and Processes, Aeronautical Systems Division, Wright-Patterson Air Force Base, Contract AF 33(657)-9149 (DDC AD No. 406145) 65N81082

PURPOSE: To present general fatigue data for 7075-T6 sheet aluminum.

ABSTRACT: This report presents S/N data points for unnotched, edge notched, fillet notched, and hole notched 7075-T6 sheet aluminum specimens having 76-87 ksi ultimate tensile strength. The axially loaded specimens, having notch factors ranging from 1.0 to 5.0 were tested at mean stress levels of 0 to 30 ksi. The associated material and test variables are specified. The information is the result of semi-automatic data processing which stores, processes, and regenerates the information in the requested form.

REVIEW: This paper is a presentation of data pertaining to fatigue behavior of 7075-T6 aluminum sheet. The test conditions and material variables are well defined. The paper would be of value to design engineers and investigators to answer general questions and to act as a guide for further investigations. No curves are drawn through the points nor is any statistical analysis performed on them. ##

Part IV = 63N18721

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Serial Number 1811
ASQC Code 830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The Navy's requirements in electronics

AUTHOR: Col. A. C. Lowell, Avionics Division, Bureau of Naval Weapons, Department of the Navy

SOURCE: Transactions 2nd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 20, 1963, pp. 89-93

PURPOSE: To describe the need for greater reliability and maintainability in naval avionics equipment, and a program for achieving them.

ABSTRACT: The complexity and maintainability requirements of avionics equipments have been increasing while the numerical strength of trained and experienced maintenance personnel has been decreasing. The background and causes for these conditions are described, and their seriousness is emphasized. The solution is considered to lie in the application of significantly improved design techniques. A naval avionics program designed to cope with this problem is the Major Improvement in Electronic Effectiveness Through Application of Advanced Techniques (MEETAT) program. Four phases of MEETAT are:

1. Development of the repairable or throwaway modules, such as the replacement plug-in boards for the A2F and W2F computers.
2. Development of the maintenance module replacement, involving the application of modular construction avionics equipment.
3. Development of functional module replacements. These are functional mission-oriented equipments.
4. Development of fully integrated avionic systems, to utilize modular construction, visual fault location, standard circuits, and replaceable throwaway cards.

The major cost to the service of owning complex equipment lies not in its initial cost, but in its maintenance and support. The lifetime cost of ownership of many high performance equipments reaches four to ten times its initial cost. Therefore, the achievement of major gains in reliability and maintainability will mean savings of hundreds of millions of dollars, as well as improved mission effectiveness. (Author in part)

REVIEW: This is a brief but clearly-presented description of a serious condition demanding decisive directed effort in order to achieve a solution. The program which is outlined appears to be a reasonable approach. It will be of interest to hear more about its implementation as time goes on. The designer must create a design which is capable of meeting specifications; the specifications should adequately describe the conditions and circumstances under which the equipment must remain operable. ##

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Serial Number 1812
ASQC Codes 824;882

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Weapon system availability models and the estimation of their parameters

AUTHOR: N. Kaufman, Space Technology Laboratories

SOURCE: Transactions 2nd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 20, 1963, pp. 95-111

PURPOSE: To describe two basic types of mathematical models which can be used with available data to determine availability.

ABSTRACT: This paper describes two basic types of mathematical models which can be used in conjunction with available data to determine availability. The first type of model deals with systems which are checked out only periodically, while the second-type model treats systems which are checked (monitored) continuously. An objective in developing these models was to include both hardware deficiencies and those attributable to personnel and procedures. In addition, statistical procedures are analyzed which take advantage of accidental or deliberate perturbations of the normal maintenance policy in order to estimate the model parameters.

Availability can be thought of as the expected proportion of time over the long run that the weapon system is assigned to a ready-for-use status and in fact is usable. There are two primary causes of non-availability, which correspond to the above two requirements: (a) the system is down for maintenance and is therefore not assigned as ready for use, or (b) the system is up (assigned as ready for use) but in fact is in a failed state (contains an undetected malfunction). (Author in part)

REVIEW: This paper is a detailed mathematical presentation. Not all of the mathematics was checked, but the approach appears reasonable. In any event, the reader interested in following the discussion closely will want to work through the derivations in order to be sure they are understood. The author has been very careful in stating his assumptions clearly and completely. He is also frank about the fact that they are highly idealized. This, of course, is not unusual in mathematical treatments of physical situations. The important thing is that the user be aware of the assumptions and the limitations which they impose. ##

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Serial Number 1813
ASQC Code 810

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability testing

AUTHOR: George A. Henderson, Martin Company, Orlando, Florida

SOURCE: Transactions 2nd Annual Quality Control-Reliability Conference, sponsored by Long Island Section ASQC, Hempstead, Long Island, New York, April 20, 1963, pp. 113-119

PURPOSE: To examine the relationship of reliability testing to other elements of the reliability program.

ABSTRACT: There are two reasons for conducting a reliability test: (1) to verify that the established reliability goals of design have been met, and (2) in case the goals were not met, to provide a measure of the variance so that the designer knows where he is with respect to the goals. There is no point in assigning unrealistic goals, the verification of which would require an intolerable amount of testing. In order to obtain a valid measure of reliability, whether it be in terms of MTBF, MTTF, Safety Factor, or Safety Margin, it is necessary to test to failure.

The author advocates the following sequence in a contractor's plant, in delivering a reliable product. First, establish proper goals for reliability (they must be measurable in some practical manner). Second, design towards these goals. Third, test to failure in order to measure the degree of attainment of the goals. Fourth, assuming the goals have been met, test to failure first production hardware, and on a continuing basis, a sample throughout the production phase.

It is suggested that the Department of Defense could take a giant step for reliability if they sponsored a two phase effort as follows. First, to cause to be developed standard test methods, procedures, and fixtures for both parts and components as a basis for standardized reliability testing; and second, to require that all parts and components be <u>tested to failure</u> under these conditions as a prerequisite to being acceptable by DOD contractors. (Author in part)

REVIEW: This paper makes a strong case for the importance of proper reliability testing. The points are clearly and forcefully presented. The suggestions for improving the situation seem reasonable, and are worthy of the thoughtful attention of those who are in a position to implement them. ##

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Serial Number 1814
ASQC Code 830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability design techniques for the design engineer

AUTHOR: Robert C. Wood, Electronic Systems Division, Fairchild Stratos Corporation (presently with Gyrodyne Company of America, Inc., St. James, New York)

SOURCE: Transactions 2nd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 20, 1963, pp. 135-154

PURPOSE: To present some of the reliability design techniques that the working design engineer can utilize and integrate with his performance design techniques during the paper design phase of a product.

ABSTRACT: This paper reviews and describes certain reliability design techniques that can be applied and integrated during the early design phases. These techniques are correlated with the performance-type design techniques, showing how they are part of the integrated design. Topics covered include

Systems and circuit design,
Systems design integration,
Integrated block diagram,
Circuit design integration,
Worst case analysis,
Circuit tolerancing technique,
Failure mode analysis,
Failure effects analysis,
Failure mode and effect design technique, and
The integrated design approach.

A detailed example of the use of a reliability integrated block diagram is given.

REVIEW: This paper covers a wide range of topics in the area of systems and circuit design. Consequently no topic is treated in great detail. At the same time, the listing of techniques is not intended to be exhaustive. However, the paper should be of interest and value to the design engineer. The integration of design techniques for both performance and reliability is emphasized. The example, which constitutes the last half of the paper, is given in a commendable amount of detail. The references cited are, for the most part, general in nature and are not keyed specifically to the topics discussed. ##

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Serial Number 1815
ASQC Code 830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Accuracy of a design-stage reliability prediction

AUTHOR: R. H. Gauger, Hazeltine Corporation, Little Neck, New York 11362

SOURCE: Transactions 2nd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 20, 1963, pp. 155-165

PURPOSE: To provide a survey of design-stage reliability prediction and its accuracy.

ABSTRACT: Specifying a reliability program is becoming a standard practice in the procurement of military electronic equipment. As a result, design-stage reliability predictions are almost universally employed. The prediction, and frequently the method to be used, is required by the contract, the equipment specification, or referenced documents. In some cases, a prediction is accepted as an indication of compliance with the reliability design requirements.

The available prediction techniques are surveyed briefly. Reference is made to the following documents: RCA TR-1100, RADC Reliability Notebook, MIL-HDBK-217, NAVSHIPS 93820 (TR-133), and Vitro TR-80 and TR-98. The importance of selecting the appropriate prediction method and of having failure rates which are applicable to the actual environment and operating conditions is discussed. Some comparisons of predictions with test results are cited. Several pitfalls in the use of the referenced procedures are pointed out. The benefits of a prediction are outlined. It is concluded that many factors may limit the accuracy of a design-stage prediction. In spite of this, a prediction, properly used, provides the best available guide for the design, part selection, and packaging of military electronic equipment required to meet a reliability specification. (Author in part)

REVIEW: This paper is a brief survey of the subject of design-stage reliability prediction, with emphasis on its expected accuracy. As such, it will be of value to those interested in a quick look at the subject. While the paper does not give details, pertinent documents are mentioned, and some 18 references are cited. In a private communication, the author has pointed out that there are typographical errors in Table 3 on page 165. The figures in the last line should be divided by 10, i.e., they should be 0.484, 0.232, and 1.78. ##

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3/65 65A18711

Serial Number 1816
ASQC Codes 831;846

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Predicting design adequacy for mission environment

AUTHOR: I. Doshay, Space-General Corporation, El Monte, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 1-11

PURPOSE: To describe a technique for the analytical evaluation of the design adequacy of equipment in the conceptual stage of development. 65A18710

ABSTRACT: The need for aerospace equipment to perform reliably in mission environments poses a formidable problem to aerospace engineers, because of the lack of realistic applications effects analysis needed to predict the adequacy of system performance. This paper describes a technique involving a computer program that utilizes component performance characteristics data and dynamic performance equations of the system in terms involving component parameter coefficients. Performance of the system in the mission environment is simulated by reproducing environmental forcing functions to alter system performance coefficient values in the anticipated time sequence profile of the mission. The technique was demonstrated by evaluating a fine attitude control system design in a hypothetical orbiting reconnaissance vehicle of anticipated 1975 era vintage. The results of the test evaluation clearly illustrate that the new technique would disclose shortcomings of designs from the viewpoints of component application and system configuration not currently discernible through worst-case analysis and other known techniques. Through the use of this it is estimated that time for space system development efforts may be cut in half while costs may be reduced by one-third.

Current reliability technology is briefly reviewed. The simulation modeling of system dynamics is described. The demonstration of environmental resistance is outlined for the particular system considered. Results and conclusions are summarized.

REVIEW: The simulation program described in this paper represents a reasonable approach to the problem of predicting the reliability of systems on which there is very little realistic data. It must be realized, of course, that simulation is a limited substitute for physical testing, and, as data are acquired, actual results should be compared with the predictions with a view to possibly updating the prediction techniques in the light of experience. It is also important not to lose sight of the dependence of the predictions on the validity of the input data on which they are based.

Other papers on this program have been covered by Abstracts and Reviews Serial Numbers 1237 and 1770. ##

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65A18712

Serial Number 1817
ASQC Codes 831;837;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Circuit design reliability by high speed computer

AUTHORS: K. D. Pope III, R. A. Mammano, and E. P. Schneider, Western Division, ARINC Research Corporation

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 12-20

PURPOSE: To describe a computer program for use in circuit design analysis and to illustrate its use.

ABSTRACT: A computer program has been developed for use as a general engineering tool which can be directly applied to many circuit problems. All that the analyst must do is reduce the circuit to a general format, decide which computations he desires, and define the parameter data. This can be done without a knowledge of computer programming or the assistance of a programmer.

The circuit must be describable as a linear equivalent circuit in terms of n linear equations in n unknowns. The equations may have real or complex coefficients. Nonlinear circuits may be analyzed by making incremental linear approximations. The different types of analysis options provided by the program include (1) one-at-a-time parameter variation, (2) special solutions based on unique combinations of circuit values, (3) worst-case solutions with all components at their drift limits, and (4) a Monte Carlo analysis to determine the possible large-volume production spread of circuit performance.

The use of the program is illustrated through application to the analysis of a single stage, common emitter transistor amplifier with two sources of negative feedback. On the basis of histograms of the particular circuit output variable chosen and other output data, conclusions are drawn with special emphasis on computational speed and cost.

REVIEW: This paper describes a particular computer program for circuit analysis, and the various computations which it can perform. It should be quite useful in analyzing the design adequacy of circuits of the type to which it is applicable. No statement is made regarding a limit on the size of the circuit (in terms of number of equations) which can be handled. No information is given as to the availability of the program to those who might wish to obtain it. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Computer aided circuit reliability analysis

AUTHORS: B. O. Allen, D. R. Blazek, and C. H. Purdue, Sandia Corporation, Albuquerque, New Mexico

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 21-33

PURPOSE: To describe briefly a reliability program for system testers and to show how computer circuit programs can be used as a technique to decrease analysis time.

ABSTRACT: A reliability program for the design of various manual and automated types of system testers is briefly reviewed. It is indicated that considerable analysis and design time savings can be achieved by using computers and programs such as the general purpose circuit analysis program, NET-1.

Schematic diagrams of two circuits analyzed by the NET-1 program are presented. The necessary input data and plots of the observed and NET-1 predicted output waveforms are also included. Some of the limitations and problems in using the NET-1 program are discussed. Plans in process are presented which, upon completion, will make the NET-1 program even more useful and universal. The input and output data for two in-house programs for specific circuit configurations are presented. (Authors in part)

REVIEW: This paper summarizes the NET-1 network analysis program, the input constraints, and the limitations experienced in using the program. The description of future work to overcome the limitations is interesting. One limitation not emphasized but which may be important is that of data pertaining to the parameters of the models for the transistors and diodes, particularly for future work in parameter variation when standard deviations and correlations of the parameters are required. These programs will be more useful if more industries and agencies can make them a part of their reliability analysis procedures when detailed circuit analyses are required. The comparison of observed characteristics with predicted values by NET-1 is useful and such comparisons are to be encouraged. ##

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65 A18714

Serial Number 1819
ASQC Codes 814;835;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A reliability/cost of ownership approach to microavionics

AUTHOR: John R. Lennon, Airplane Division, The Boeing Company, Renton, Washington

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 34-40 (The following paper by the same author is similar to this one: Paper 2.1, 7 pp., presented at the 1964 Western Electronic Show and Convention (WESCON), Los Angeles, California, August, 1964)

PURPOSE: To show that microelectronics can play an important part in improving the reliability of avionic equipment.

ABSTRACT: A study of the physics of failure of semiconductor integrated circuits indicates that microelectronics can improve the reliability of avionics. Over 100 million circuit hours gives a quantitative indication that microelectronic circuits have over an order of magnitude advantage in MTBF over standard discrete equivalent circuits. An analysis of systems shows that this reliability improvement coupled with size, cost, and maintainability considerations gives microavionics a cost of ownership advantage over conventional systems.

A semiconductor integrated circuit can be expected to be more reliable than an equivalent conventional circuit because it exhibits the following characteristics which show reduced severity of several failure mechanisms of the conventional approach: (1) decreased complexity, (2) improved connections, (3) decreased mass, (4) improved process control, (5) reduction of the human element, (6) standardization, (7) improved design, and (8) maintainability. These characteristics are discussed in the paper.

Available quantitative reliability data on semiconductor integrated circuits are described under the headings: operating life tests, accelerated testing, and environmental testing. Microavionics reliability is compared to other current approaches through a study based on hypothetical designs. A brief discussion of the cost of ownership of microelectronics is given. (Author in part)

REVIEW: This is a fairly detailed presentation of the advantages of the microcircuit in terms of physics of failure, quantitative data, reliability prediction, and cost of ownership. As such it is worthy of the attention of designers. While the specific reference in the paper is to applications in manned aircraft, most of the principles would apply also to spacecraft use. ##

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65A18715

3/65

Serial Number 1820
ASQC Codes 872;882

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A practical reliability and maintainability model and its application

AUTHORS: E. J. Althaus and H. D. Voegtlen, Hughes Aircraft Company, Culver City, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 41-48

PURPOSE: To present the essential approach to the development of a practical reliability and maintainability model and to describe the application to a modified weapons system.

ABSTRACT: A reliability and maintainability model is developed. The model represents a compromise between the complexities of exact Markov simulation and the crude availability formula approach. A unique feature of the model is the use and the manner of determination of the undetected failure rate in the system. The model is applicable to those systems having integrated self-test capability, where it is possible to determine whether the failure of a single element would be detected by the self test. The model includes the development of a self-test efficiency measure tied to reliability calculations and the consideration of queueing effects.

The parameters of interest are those most commonly evaluated such as MTBF, periodic maintenance interval, and repair time. The failure and repair rate characteristics are assumed to be that of an exponential distribution. For purposes of simplification only the expected values are used, although computer simulation of the model can yield the range of values that would occur with any desired confidence. No greater than two-significant-figure accuracy is claimed for the model and it will probably be less.

Expressions are obtained for operational availability in terms of apparent availability and readiness probability with and without periodic maintenance. An application of the model to a modified weapons system is given to illustrate the modeling procedure and tradeoff possibilities.

REVIEW: This paper introduces several new maintainability concepts for systems having self-test capability, where it is possible during the design stage to segregate parts into those detectable or non-detectable in the failed state. The application to a modified weapons system aids the reader in understanding the procedural steps and illustrates the type of results to be expected. There are a few typographical errors in the example which are obvious to the reader who follows the details of the procedure. ##

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3/65 65A18716

Serial Number 1821
ASQC Code 870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Maintainability prediction for avionic equipment

AUTHORS: G. H. Griswold, RCA Service Company, A Division of Radio Corporation of America, Cherry Hill, New Jersey and D. A. Topmiller, Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 49-58

PURPOSE: To determine if the Rome Air Development Center (RADC) maintainability prediction technique can be used for maintenance environments other than the one for which it was developed (ground organizational maintenance), and if consistent results can be obtained when the technique is applied by different personnel.

ABSTRACT: This paper describes the RADC maintainability prediction technique for ground organizational maintenance. The description includes the assumptions, measurement techniques, field study, data analysis, formulation, and validation.

The program to determine if the RADC prediction technique can be adapted for use on airborne electronic equipment consists of four steps: (1) adapting the technique to the airborne environments, (2) training personnel in the use of the technique, (3) performing trial predictions, and (4) comparing the results of the predictions with criterion data obtained from field operations. The down time was predicted for several failure modes (identified by tasks in the paper) for a representative airborne equipment by both RCA and Aerospace Medical Research Laboratory (AMRL) personnel working independently. The predictions were compared with field data. The ability of four personnel with different backgrounds to obtain consistent predictions for five of the total of forty tasks was measured. The RCA and AMRL predictions were in good agreement; however, the agreement among the predictions by different personnel on individual tasks was poor. The predictions compared unfavorably with the field data, and the possible implications of this difference are noted.

The broad implications of the program are discussed and the needs for further research are indicated. The validity of the technique for airborne field maintenance remains to be determined; however, it can be used to provide comparative evaluations.

REVIEW: This paper makes a real attempt to answer some practical questions in the application of a maintainability prediction technique. One unique feature of the evaluation program is to determine if consistent results can be obtained by several personnel using the technique. Applications of this nature can result in an improved technique. ##

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65 A15717

Serial Number 1822
ASQC Code 875

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A case study in maintainability

AUTHORS: J. W. Bogle, Raytheon Company, Wayland, Massachusetts and J. Sacks, Bureau of Ships, Washington, D. C.

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 59-67

PURPOSE: To evaluate the BuShips maintainability specification, MIL-M-23313, by applying the prediction and demonstration to a system presently being procured by BuShips.

ABSTRACT: The paper describes the maintainability prediction technique employing the procedures and data of MIL-M-23313. The prediction method requires that seven (7) discrete time elements be established for each replaceable part or module. This portion of the evaluation was the most extensive. Subsequently the demonstration test is described. A navy technician was employed and the test conducted on an evaluation model system installed in a Navy Destroyer.

A quantitative and a qualitative critique is given of the prediction and demonstration procedures. Some of the problems encountered in applying the technique are presented and suggestions for improvements are indicated.

Twenty failures were induced in the evaluation model system which was installed in a Navy Destroyer. In three of the twenty cases the predicted and demonstrated repair times were almost equal. The remainder of the demonstrated times are less than those which had been predicted. Several possible explanations of these differences are discussed.

REVIEW: An evaluation program of this nature does indicate possible improvements in the maintainability prediction and demonstration techniques. It seems that a method for demonstrating maintainability in a manufacturer's plant is desirable even though it was decided to perform the evaluation aboard ship. The authors point out the fact that this was a single evaluation using only one radar system and one technician and that only preliminary conclusions can be drawn. This is particularly true in comparing the predicted and demonstrated repair times. ##

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G

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Management and training--a tutorial paper

AUTHOR: M. M Tall, Administrator, Defense Reliability and Maintainability, Radio Corporation of America, Camden, New Jersey

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 68-71

PURPOSE: To discuss some of the considerations involved in reliability management and training. 65A19710

ABSTRACT: Reliability management and organization continue to be important topics of discussion among reliability personnel. Some of the questions generally considered are (a) whether reliability is a line or staff function, or a combination of both, (b) what the division of responsibility between design and reliability should be, and (c) what proportion of contract funding should be allocated to reliability. There are no magic formulae which yield the answers to these questions.

The reliability engineer can be a contributing part of the design team. In this role, closeness in terms of organizational and physical location can be an asset. On the other hand, the audit and monitoring function of reliability can be hampered by too close a relationship to the design organization. The organization must be such that both of these aspects can operate effectively.

Allocation of funds to the reliability effort should be worked out for each individual project on the basis of adequate analysis and planning. A successful reliability program requires the integration of the mathematical and physical approaches, making optimum use of all of the available tools in order to accomplish its objective. Reliability engineering is not a single specialty, but includes a spectrum of disciplines.

The first step in the training of reliability practitioners is to provide them with the broad picture, enabling them to see the part which their skills can play in achieving the over-all objective. Reliability should be presented as a dynamic field of endeavor, in which current techniques represent a particular stage in our growth. There is still the need for the contribution of those who question and seek new answers.

Following a presentation of the complete picture, each group of specialists can explore in depth the application of their particular skills to the reliability program. Those already in the reliability field must be kept abreast of new developments. This looms as a major difficulty, particularly because of the proliferation of papers presented and published. From among these, there

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is a need to select the few gems which may be hidden among the noise, and to convey these gems to reliability personnel. Ways of doing this effectively must be found. In all of this, it must be kept in mind that there are no magic solutions and no substitutes for thought.

REVIEW: This is a good brief paper which accomplishes its purpose quite well. It is not intended to be a treatment of the specifics of management and training, but rather a discussion of some of the more important facets of the underlying philosophy. As such, it is worthy of the thoughtful attention of reliability managers and those responsible for reliability training programs.

The reader may be puzzled by the word "inorators" which appears in the paper. The author, in a private communication, has advised that this resulted from a consistent typographical error; the intended word was "innovators." ##

65A18718

Serial Number 1824
ASQC Codes 821;822

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability mathematics and prediction

AUTHOR: Ralph E. Kuehn, International Business Machines Corporation, Space Guidance Center, Owego, New York

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 72-75

PURPOSE: To present a brief description of some mathematical results and their application to reliability problems.

ABSTRACT: Probability distributions are of considerable interest in reliability work. The most important discrete distributions encountered are the binomial and the Poisson. These are described briefly. Of continuous random variables important to reliability, the most common densities are the normal (Gaussian), gamma, Weibull, and exponential. The density functions for these are cited and some remarks are made regarding their application. Other topics briefly discussed include reliability prediction, reliability allocation and apportionment, reliability growth, part improvement, and simulation studies. Ten references are cited, mainly to papers published in Proceedings of previous National Symposia on Reliability and Quality Control.

REVIEW: This paper presents essentially a glimpse of the subject of reliability mathematics and prediction. The references cited are not the most suitable for the person who wishes to get the details on this subject. For this purpose it would be better to refer to some of the recent textbooks which have been published. A useful description of seven of these is found in the paper covered by Abstract and Review Serial Number 1702. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Design review--tools and techniques

AUTHOR: Marion P. Smith, Honeywell Inc., 13350 U. S. Highway 19, St. Petersburg (33733), Florida

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 76-82

PURPOSE: To describe some of the techniques which the reliability engineer or design engineer may profitably employ in his own operation so as to enhance the value of design review.

ABSTRACT: The value of design review is enhanced if certain key tasks are performed during the design stage with the results brought in to consider during design review. Some of these key tasks are: (1) circuit analysis or tolerance testing, (2) the use of proper guides for reliable parts application and (3) reliability stress analysis. This paper discusses these as one portion of a tutorial session on reliability fundamentals.

The general procedure in using computer techniques to determine the effect of part parameter tolerances and drift on the circuit performance is outlined. The use of analog tester analysis is described. The use of guides for reliable parts application is discussed and illustrated. The value of stress analysis is indicated, and a preferred method of executing it is given. A bibliography of some 23 items is included. (Author in part)

REVIEW: This is a concise tutorial paper dealing with certain design-stage tasks which can favorably affect the value of design reviews. The concern is with these tasks rather than with the management, scheduling, or conduct of the actual design reviews. Material on the latter aspects can be found in the references cited in the paper. An earlier paper on design reviews by the same author was covered by Abstract and Review Serial Number 1203. The review of that paper mentions some 21 other papers on design reviews. In addition to these, see also Abstracts and Reviews Serial Numbers 1213, 1536, 1614, and 1617. ##

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ASQC Codes 813;815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability evaluation

AUTHOR: John E. Condon, Office of Reliability and Quality Assurance, National Aeronautics and Space Administration, Washington, D. C.

SOURCE: Transactions 3rd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 4, 1964, pp. 1-5

PURPOSE: To describe Section 4 of the NASA specification NPC 250-1 and the philosophy behind it.

ABSTRACT: In this paper the unique features of NASA programs are discussed. These have resulted in NASA's Space Exploration Council establishing a reliability program policy requiring continued analyses of system reliability and an associated test program to demonstrate, insofar as possible, achieved reliability. This policy led to Section 4, "Testing and Reliability Evaluation," of the specification NPC 250-1, "Reliability Program Provisions for Space System Contractors."

REVIEW: The papers by the same author covered by Abstracts and Reviews Serial Numbers 1495 and 1761 are similar to this one, which, in addition to describing Section 4 of NPC 250-1, discusses the reasons behind its particular requirements. ##

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Serial Number 1827
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Quality and reliability program of the Department of Defense

AUTHOR: George E. Fouch, Deputy Assistant Secretary (Equipment Maintenance and Readiness), Department of Defense

SOURCE: Transactions 3rd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 4, 1964, pp. 7-9

PURPOSE: To describe recent actions taken to strengthen the quality program of the Department of Defense.

ABSTRACT: The increasing complexity and costliness of weapons systems and equipment have focused attention on the urgency of attaining high levels of quality and reliability at reasonable costs. With so much product innovation in the newer industries there is need for continuing vigilance to make sure that quality control is revitalized from time to time so that it is capable of confronting and resolving the challenges that inevitably come with industrial and technological progress. In December 1963 DoD issued two quality assurance specifications that are important instruments for improving quality and reliability of DoD material. MIL-Q-9858A, "Quality Program Requirements," is designed for application in the procurement of complex weapons and equipment where meticulous care by the contractor is essential in all aspects of contract performance to assure compliance with stringent quality and reliability requirements. MIL-I-45208A, "Inspection System Requirements," is applicable to contractors supplying items of relatively noncomplex design and contains less stringent requirements. These specifications have had extensive coordination throughout DoD activities and among the major Industry Associations.

The new MIL-Q-9858A emphasizes quality program management throughout all phases of contract performance including design, development, fabrication, processing, assembly, inspection, testing, packaging, and shipping. All material is adequately controlled. Provision is made for the prevention and detection of discrepancies and for corrective action. The contractor is required to maintain and use quality cost data.

Other steps taken include the development of handbooks for the guidance of DoD quality assurance personnel and the specification of calibration system requirements. Significant progress has been made in incorporating quantitative reliability requirements and procedures into specifications for those electronic parts essential for reliable performance of weapons and equipment. (Author in part)

REVIEW: This is a very brief paper, but it serves its purpose well in summarizing the objectives of these two DoD specifications. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Some economic concepts underlying reliability engineering

AUTHOR: P. S. Darnell, Bell Telephone Laboratories, Incorporated, Whippany, New Jersey

SOURCE: Transactions 3rd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 4, 1964, pp. 11-23

PURPOSE: To consider briefly some of the economics of reliability in relation to electronic systems and equipment.

ABSTRACT: There is evidence of a growing sensitivity to the economic factors associated with improvement in reliability. The background for this trend is traced briefly. One of the economic concepts underlying reliability engineering pertains to the interrelation of system costs associated with development and design, procurement, operation, maintenance, and logistics. It is desirable to achieve an economic balance among the costs represented by these factors such that the total cost to the user over system lifetime is a minimum. Some efforts in applying a quantitative approach in establishing this balance are cited. A second economic concept underlying reliability engineering has to do with the costs of demonstrating or verifying that systems (and their parts) can meet stated reliability requirements. The high levels of cost and prohibitive test times are the great concerns here. Some of the salient features of a study of this problem are presented. A third area of interest and importance is that pertaining to the components of systems. Funds devoted to parts improvement should be such as to optimize the resultant system reliability gains. Tests must be carefully designed so as to produce a maximum amount of information per dollar expended.

A basic economic concept fundamental to reliability engineering is that of determining solutions which lead to optimum economic balances under conditions which apply to each specific problem. Circumstances leading to the failure levels and associated repair costs cited in the paper must not be tolerated. The economic phases of reliability engineering face both challenges and opportunities to point the way to better reliability at all levels of system generation.

REVIEW: This paper presents forcefully and clearly the value and importance of applying economic appraisals as a part of reliability engineering. The results of so doing should be optimum system performance at the least cost. In presenting his case, the author makes effective use of references to the literature in this topic area (see, for example, Abstracts and Reviews Serial Numbers 1199, 1230, 1271, 1297, and 1431). ##

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Serial Number 1829
ASQC Code 810

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Management of reliability in weapon systems development programs

AUTHOR: E. J. Nucci, Office of the Director of Defense Research and Engineering

SOURCE: Transactions 3rd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 4, 1964, pp. 31-40

PURPOSE: To summarize some of the concepts, policies, and efforts related to reliability, maintainability, and improved development program management.

ABSTRACT: In the implementation of sound reliability and maintainability policies, there is a need for the military to establish quantitative goals based on a complete analysis of military missions. These goals become the basis of technically realistic contractual requirements and appropriate demonstration plans. The policies establish reliability and maintainability on a total system basis, with achievement a direct function of sound engineering. Reliability monitoring is essential; the direct responsibility for system reliability and maintainability rests with the project manager, the line manager.

Development management policies are listed. The following development management techniques are described briefly: Reliability Status Survey on Selected Systems in RDT&E, Technical Development Plans, Reliability and Maintainbility Techniques, Consolidation of Reliability Specifications, Parts Specifications Management, Project Definition Phase, and PERT/Cost. Future efforts are discussed under the headings (1) specific reliability research needs, (2) advanced technology, and (3) system effectiveness. It is concluded that from a management standpoint, the primary objective should be a more complete utilization of available techniques which will contribute to the achievement of established goals.

REVIEW: This is a good statement on the management of the reliability function in weapons systems development programs. As such it should be of interest and value to line managers, design engineers, and contract negotiators. The responsibility of management in both the military and industry for the effective planning and execution of the program is clearly brought out. ##

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Serial Number 1830
ASQC Code 813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Assessing the value of a reliability/quality control program

AUTHOR: Paul G. Atherton, ITT Federal Laboratories, Nutley, New Jersey

SOURCE: Transactions 3rd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 4, 1964, pp. 59-97

PURPOSE: To discuss the measurement of the effectiveness of a reliability/quality control function.

ABSTRACT: The effectiveness of an auditing, preventive, and controlling function is often measured in terms of the negative aspect--e.g., by the dollars which were not lost because an error or oversight was exposed in time. Such is the case with the reliability/quality control function. This theme is discussed through the medium of a series of selected examples. These pertain to the following periods in the life cycle of a piece of electronic hardware:

1. Proposal and Specification
2. Research and Development
3. Production and Test
4. Use.

The importance of the reliability/quality control function being part of the team from the proposal stage to the wearout of the equipment is emphasized.

REVIEW: This is a rather long paper, due to the format used--that of citing specific examples. The effect is to present the main theme (cited in the last sentence of the above ABSTRACT) in a rather engaging way. ##

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Serial Number 1831
ASQC Code 830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An analysis of design assurance

AUTHOR: Karle S. Packard, Airborne Instruments Laboratory, Division of Cutler-Hammer, Inc.

SOURCE: Transactions 3rd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 4, 1964, pp. 119-131

PURPOSE: To discuss design assurance and its effectiveness.

ABSTRACT: Programs for design assurance may vary widely in both breadth and depth of activity, depending on the product, the customer, the delivery schedule, etc. Although many of the individual tasks included in such programs are widely accepted, it is usually necessary to plan a specific program to satisfy a specific situation. A well-planned program must be based on a full appreciation of the role of design assurance in the context of the specific situation and this, in turn, can only result if its essential function is fully understood. Evidence of the need for design assurance, as well as for awareness of this need is found in the following results of a recent AF survey: (1) many design changes needed to correct earlier design oversights, (2) generation of system and interface specifications late in the program, (3) many design incompatibilities revealed in system test, (4) many reliability considerations made on an after-the-fact basis rather than in initial design. (5) unilateral design releases without design review, (6) engineering decisions not supported by analysis; trade-offs not identified, (7) management prone to correct only the visible problems rather than the basic cause, and (8) tendency toward excessive "management by exception" without adequate procedural control.

The function of design assurance is discussed from a theoretical standpoint. The elements of design assurance are presented in critical terms, to assist in their application to specific programs. Some measure of the effectiveness of such programs is described. It is pointed out in conclusion that the program should be systematic and methodical to ensure proper coverage, but it should never be allowed to become so routine that form is used as a substitute for judgment. (Author in part)

REVIEW: This is a good compact discussion on design assurance and the techniques which it involves. Given the evidence that design assurance is not well understood, this paper should serve a useful purpose. There remains the application of the ideas to the specific program of interest to the user. In this connection, the experience and competence of the individuals carrying out the program will be most important. ##

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Serial Number 1832
ASQC Codes 813;816

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The effect of contractor relationships on product reliability

AUTHOR: J. T. Tambini, Reliability Control Section, Grumman Aircraft Engineering Corporation

SOURCE: Transactions 3rd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 4, 1964, pp. 133-140

PURPOSE: To discuss the importance of compatibility between prime and subcontractor in conducting a reliability control program.

ABSTRACT: Companies engaged in pooling their resources and talents in the development and production of complex industrial and military products must have a high degree of mutual understanding and cooperation. The specification and determination of the degree of reliability of the equipment can be a problem area. Reliability can often be relegated to a minor role, unless the reliability control engineer takes positive action to avoid this.

The subcontractor's reliability engineer should first perform a thorough study of the design and its specified requirements, then configuration analyses of all competing designs under consideration. During design and development he should conduct failure effect analyses. He should keep himself informed of his customer's standards with regard to preferred parts, manufacturing techniques, and recommended practices. He should decide whether a modal analysis is necessary, make a reliability assessment of his company's design as soon as possible, updating it at suitable intervals, and ensure that all tests are planned to yield the maximum information.

The prime contractor's reliability engineer must compute the apportioned reliability requirement to be assigned to the vendor's product, and explain this requirement fully to the subcontractor. He should maintain adequate surveillance over all tests and corrective action efforts. He is responsible for configuration analyses, failure effect analyses, reliability assessments, and modal analyses--all from the point of view of the entire system. He should determine where the subcontractor needs guidance and assistance, and reapportion reliability goals where necessary and possible. Compatibility between prime and subcontractor is the key to a successful program.

REVIEW: This is a very readable paper, and the ideas presented in general seem reasonable and straightforward. Most of them are not likely to be new to experienced reliability engineers, but this type of paper can serve a useful purpose in calling attention to them. This type of program can be rather expensive and time-consuming; allowance should be made for it in contractual negotiations. ##

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Serial Number 1833
ASQC Code 870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Maintainability--a reality not a myth

AUTHOR: Lt. Colonel E. R. Fallon, Jr., USAF, Materiel and Support Division, Logistics Directorate, Organization of the Joint Chiefs of Staff

SOURCE: Transactions 3rd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 4, 1964, pp. 141-149

PURPOSE: To discuss the meaning and importance of maintainability.

ABSTRACT: Maintainability is a planning and design consideration to assure the customer that he will receive a system which will meet performance requirements and which can be supported expeditiously and economically. As such, it is an important factor for cost reduction and increased efficiency in all military services. There are four building blocks for a stable maintainability program. These are:

1. All documents associated with the planning, management, technical and contractual elements of a project must include, from the beginning, the definitive support requirements and design constraints.

2. On the basis of the specified quantitative support requirements and design constraints, the estimated costs of attaining the requirements and follow-on support during the operational phase, in terms of resources and funds, must be predicted during program definition.

3. Systematic analyses and demonstrations must be conducted at established milestones during the definition and acquisition phases.

4. The cost of achieving maintainability must be recognized as a valid element in the over-all cost of the system from concept to end use.

The importance of achieving increased readiness through improved maintainability is discussed. The maintainability activities of the military departments are described briefly.

REVIEW: This paper discusses maintainability from the point of view of the military, and gives a brief picture of the actions being taken by the three services to ensure that maintainability will continue to be increasingly important and effective. The general impressions which it conveys should be of interest to those concerned with the design and production of military equipment and systems.

The author, in a private communication, has advised that the planning aspects for maintainability dealing with logistic support have been expanded and covered in DoD Directive 4100:35, "Development of Integrated Logistic Support for Systems and Equipments." ##

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Serial Number 1834
ASQC Codes 814;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Maintainability and its effect on the cost of system readiness

AUTHOR: John E. Losee, Republic Aviation Corporation

SOURCE: Transactions 3rd Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, April 4, 1964, pp. 151-160

PURPOSE: To present a cost-effectiveness formula to show the return to the customer from money invested in maintainability.

ABSTRACT: Maintainability is now generally included as a performance requirement in contracts for military equipment and systems. Questions naturally arise as to the cost effectiveness of maintainability requirements. This paper presents a cost effectiveness formula designed to show the return to the customer for every dollar invested in maintainability. The formula expresses the cost-effectiveness ratio (amount saved/amount spent) in terms of some 16 parameters which must be estimated from available data and experience. Illustrative values are given for the estimated parameters and the use of the formula is demonstrated. Some ramifications of the analysis of cost relationships are discussed. The need for maximizing up-time on expensive systems is emphasized.

REVIEW: The problem treated in this paper is important, and it would be useful to have a valid quantitative way of handling it. The formula presented represents one approach, and seems reasonable. The critical factor in applying it to a specific system will be that of having good estimates for the 16 parameters which are involved. Perhaps the major contribution of the paper lies in the stimulation of interest in further analysis in this area. The ultimate objective of standardized techniques is very worthwhile. ##

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Serial Number 1835
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Incentive contracts and the reliability riddle

AUTHOR: Vernon L. Grose, Rocketdyne, A Division of North American Aviation, Inc., 6633 Canoga Avenue, Canoga Park, California

SOURCE: Quality Assurance, vol. 3, November, 1964, pp. 18-21

PURPOSE: To discuss the topic of incentive contracting and reliability in the aerospace and electronics industry.

ABSTRACT: Profit is a basic element of free enterprise, but has become suspect in many quarters when associated with Government business. Incentive contracting developed in the aerospace and electronics industry as a "crutch" for the lack of free enterprise. Reliability incentives are primarily in the planning stage, rather than fully implemented in existing contracts. The lack of trade-off data relating reliability to costs is preventing increased use of reliability incentives. The long-standing communications problem between reliability personnel and the rest of the technical community also deters incentive contracting. Reliability is difficult to demonstrate, with the customer preferring service usage and the contractor conditions under his control.

Recommendations to the Government are:
(1) minimize the total number of incentive parameters,
(2) demonstration criteria must correlate with use conditions,
(3) the reliability portion of the overall incentive must be consequential, and
(4) consideration should be given to longer-range and more consequential factors than immediate profit (e.g. follow-on business).

REVIEW: This paper calls attention to some of the important considerations of a timely facet of reliability practices, incentive contracting. The main points which are made are pertinent to the current status of this topic. However, the accompanying discussion is involved, and rather sweeping statements are made with little clear support or illustration. The paper will be of some interest to reliability program management because of the growing attention given to reliability incentives; the above ABSTRACT contains the main points.

The author, in a private communication, has forwarded a copy of the Electronic Industries Association (EIA) report on which the article was based. The report is entitled "Reliability Aspects of Incentive Contracts," is dated 24 September 1964, and was prepared by the EIA M-5.2 Subcommittee on Reliability. References and exhibits are included in this report. Copies may be obtained by writing to the author. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A discussion on new materials

AUTHORS: (Organized by J. D. Bernal, C. E. H. Bawn, A. H. Cottrell, and F. C. Frank)

SOURCE: Proceedings of the Royal Society Series A Mathematical and Physical Sciences, vol. 282, 20 October 1964, pp. 2-154 (published by the Royal Society, Burlington House, Piccadilly, London, W.1, England)

PURPOSE: To present the results of a seminar on the strengths of new materials.

ABSTRACT: The papers in this issue are as follows:

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Serial Number 1836 -2
ASQC Codes 711;713

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

65A10272

R. N. Haward and J. Mann	Reinforced thermoplastics	120
W. E. Fitzgerald and L. E. Nielsen	Viscoelastic properties of the salts of some polymeric acids	137

In addition to newer materials, new ways of looking at old materials are presented.

REVIEW: This is an excellent series of articles for those in the fields of materials or physics-of-failure. Even the last paper, with its unlikely-sounding title, has information of value. Some of the papers discuss new materials; others describe new ways of looking at older materials. All of them are important and worthwhile. ##

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Serial Number 1837
ASQC Codes 782;835;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Tube life increased by heat-dissipating shields

AUTHOR: John C. McAdam, International Electronic Research Corporation, Burbank, California

SOURCE: Electronic Products, vol. 7, December, 1964, pp. F6, F30-F32

This paper is similar to the one covered by Abstract and Review Serial Number 779. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The fatigue resistance of reinforced plastics

AUTHORS: J. W. Davis, J. A. McCarthy and J. N. Schurb, Minnesota Mining and Manufacturing Company, Reinforced Plastics Division, 1210 University Avenue, Saint Paul, Minnesota 55104

SOURCE: Materials in Design Engineering, vol. 60, December, 1964, pp. 87-91

PURPOSE: To give data on important fatigue properties of reinforced plastics and show how behavior is controlled by choice of fiber, resin, and laminate orientation.

ABSTRACT: The reinforced plastics that are designed for fatigue resistance differ in composition and structure from most other fiber reinforced plastics. They can best be described as nonwoven, continuous glass filament, thermosetting laminates produced in the form of cured sheets or uncured prepreg rolls and sheets. Their fatigue resistance properties depend largely on fiber orientation, the type and composition of resin that is used, and the way that the composite is designed.

Nonwoven continuous glass fibers perform best in the molded fiber reinforced laminates that are used for fatigue-resistant applications because: (1) they provide higher strength than woven continuous fibers or short, randomly distributed fibers; and (2) the fibers can be conveniently oriented to put strength and stiffness where they are needed.

Glass fibers provide the highest strength of commercially available fibers, and have a high capacity for storing energy--a prime requirement for fatigue resistant materials. In addition, they have relatively low density and a lower modulus than most metals. The relatively low and controllable modulus, supplied by both the glass fibers and resin binder, means that the material can withstand deflection without producing excessive stresses. The fibers also resist chemicals and heat, and they can be fabricated efficiently in laminate form.

Of the various thermosetting resins commonly used in glass fiber reinforced laminates, the best fatigue properties are obtained with the epoxy resins. This superiority is attributed to the inherent toughness and durability of epoxy resins. In addition, they have high mechanical strength, low shrinkage during cure, and form an excellent adhesive bond to glass fibers. Also, the inherent corrosion resistance of the epoxy resin binder means that the full fatigue strength is available.

Tables show that the fatigue properties on a weight basis are

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

better for the filament-plastics than for many steels, In fact, they are better than some mild steels on an absolute basis. The stored energy is better than for steel, the notch sensitivity is much less (and thus better) than for steel, and the damping capacity is better. Tables and discussion are provided to cover all these points. They resist corrosion better than many steels. (Author in part)

REVIEW: This is a good paper on the subject, especially for those engineers not acquainted with the good properties of these filament-reinforced epoxies.

In discussing fatigue strength at 10 million cycles, and comparing it to steel, there is some implication that these reinforced plastics have a non-zero fatigue limit which is reached by 10 million cycles. Such is not the case.

In a private communication, the third author has commented as follows. "... it was not intended to imply in the paper that in all cases the S-N curve for reinforced plastics levels out at 10 million cycles. The slope of the S-N curve for example for all unidirectional laminates will continue to fall off beyond 10 million cycles. On the other hand, the slope of the S-N curve for laminates having 15-50% cross fibers will level off at 10 million cycles. This has been substantiated in actual service conditions where leaf springs with 20% cross fiber have been in service at 15,000 - 20,000 psi alternating bending stress for several billion cycles without failure. For this paper 10 million cycles was selected as the rating point because it is a standard for metals and because it is the basis for most of the available data on reinforced plastics." ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Characteristics of contact surfaces to make reliable electrical connections

AUTHOR: J. B. P. Williamson, Director, Research Laboratory, Burndy Corporation, Norwalk, Connecticut

SOURCE: Machine Design, vol. 36, May 7, 1964, pp. 172, 175, 176, 178, ←65A11519 179 (a summary of SAMPE paper, "Dependence of the reliability of electrical connections and joints on the microtopography of the mating surfaces," Chapter 12, Vol. 3, 11 pp., Proceedings of the 6th National Symposium, "Materials for Space Vehicle Use," Seattle, November, 1963)

PURPOSE: To discuss the problem of making reliable electrical joints from the viewpoint of surface physics.

ABSTRACT: The objective in any electrical joint or contact is to bring two conductors together in such a way that electrons in the lattice of one can pass freely into the lattice of the other. Contact between conductors is markedly influenced by their surface roughness. Surfaces touch first at points where the tips of asperities on one meet those on the other; the contact area grows as the asperities yield through the intense local pressure until the total contact area supports the load without further yielding. The interface between conductors behaves as a thin insulating barrier with a few small holes through which the current is constricted: this is still true when the conductors are pressed together with great force.

The most frequent cause of connector failure is that conductors become separated by an insulating film which reduces the area of metal-to-metal contact. The rate at which surface film builds up on the interface increases markedly as local temperature rises. This leads to smaller contact area, increased resistance, more heat, and eventual failure. Some techniques are described which can be used to locate the microscopic areas of contact.

The topography of contaminated surfaces is discussed with reference to the roughness of surfaces, the average slope of the surfaces, and the distribution of the sizes of the asperities.

REVIEW: The editors of Machine Design classify this as a "design abstract". As an extended abstract it serves the useful purpose of directing the reader to the full-length paper. The "design abstract" is interesting and informative albeit somewhat vague in places. For example, in the section on the electrical decoration technique, the author discusses the effect of passing a pulse of high current through a joint in order to melt the metal in the contact regions so that these regions can be detected microscopically after the

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surfaces are separated. Unfortunately he fails to mention the rise time of the pulses used, nor does he state whether the pulses were square waves or pulses of high frequency current. This information would appear to have an important bearing on the phenomena observed, and should have been given in the "design abstract".

The author, in a private communication, has pointed out that this article is a short account of the lecture which he gave (see SOURCE), and was prepared by the editorial staff of Machine Design. He has also indicated that the specific answers to the questions raised above were given in his oral presentation and are that the pulses should be between half and 5 milliseconds long, and can have any shape. A single half cycle is used. High frequency currents are not satisfactory because the skin effect tends to drive the current through the spots at the outer edges of the overall contact area only. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Corrosion in threaded fasteners...causes and cures

AUTHOR: A. Craig Hood, Manager, Research and Development, Standard Pressed Steel Company, Jenkintown, Pennsylvania

SOURCE: Machine Design, vol. 36, December 17, 1964, pp. 153-156

PURPOSE: To show how corrosion problems can be solved by selection of fastener material, protective coating, and/or joint design.

ABSTRACT: All fastened joints are, to some extent, subjected to corrosion of some form during normal service life. Design of a joint to prevent premature failure due to corrosion must include considerations of the environment, conditions of loading, and the various methods of protecting the fastener and joint from corrosion. Three ways to protect against corrosion are:

1. Select corrosion-resistant material for the fastener.
2. Specify protective coatings for fastener, joint interfaces, or both.
3. Design the joint to minimize corrosion.

Basic factors affecting the choice of corrosion-resistant threaded fasteners are:

(a) Tensile and fatigue strength.
(b) Position on the galvanic series scale of the fastener and materials to be joined.
(c) Special design considerations: Need for minimum weight or the tendency for some materials to gall.
(d) Susceptibility of the fastener material to other types of less obvious corrosion. For example, a selected material may minimize direct attack of a corrosive environment only to be vulnerable to fretting or stress corrosion.

Some of the more widely used corrosion-resistant fastener materials, along with approximate fastener tensile strength ratings at room temperature and other pertinent properties, are listed in a table.

Factors which affect coating choice are: (a) corrosion resistance, (b) temperature limitations, (c) embrittlement of base metal, (d) effect on fatigue life, (e) effect on locking torque, (f) compatibility with adjacent material, (g) dimensional changes, (h) thickness and distribution, and (i) adhesion characteristics. Three types of protective coatings are conversion coatings, paint, and electroplating. A serious problem, known as hydrogen embrittlement, can develop in plated alloy steel fasteners. Hydrogen generated during plating diffuses into the steel and embrittles the bolt. The result is often a delayed and total mechanical failure, at tensile levels far below the normal strength of the fastener. High tensile strength, high-hardness structural parts are particularly susceptible to this condition. Techniques and

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specifications for overcoming this problem are available from fastener manufacturers.

In proper joint design consider the following points. For direct corrosive attack, choose the right corrosion-resistant material. For galvanic corrosion, the fastener may be insulated from the joint in severe cases. For concentration-cell corrosion, keep surfaces smooth and clean. For fretting corrosion, use a lubricant. For oxidation or stress corrosion, choose resistant materials. For corrosion fatigue, design the joint for high fatigue life. (Author in part)

REVIEW: This is a good summary article for designers to read. While obviously not all topics are covered, the paper does give the subject a good once-over. In addition to lengthening life, good joint design can improve maintainability. ##

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Serial Number 1841
ASQC Code 800

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability facts and factors--reliability physics

AUTHOR: Robert A. Yereance, Program Director of Reliability, Battelle Memorial Institute, Columbus, Ohio

SOURCE: Systems Design, vol. 8, December, 1964, pp. 4-5

PURPOSE: To discuss the reasons for reliability physics.

ABSTRACT: Reliability physics is the identification, measurement, and understanding of processes which cause degradation and failure. There are some objections to this approach; e.g., it takes too much time and money and it does not get at the chief causes of failure. These objections tend to exaggerate specific phases of reliability physics and ignore the reasons for it. While the chief causes of failure are often lack of adequate control of mechanical processes during manufacture, these are being eliminated in many components and systems by screening and by care in manufacture. Even though studies are performed on specific devices, the results may be generally applicable to certain materials or production methods. Reliability physics allows a sound approach to screening of potential early failures.

REVIEW: This is certainly a reasonable discussion of the reasons for reliability physics. Some of the objections to it which are mentioned in the article may well have been generated by reaction to overenthusiastic claims made by some practitioners. Reliability physics does offer the main hope for tremendous decreases in failure probabilities of systems which are already well "debugged."
##

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3/65

65A26803

Serial Number 1842
ASQC Code 775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Nondestructive testing

AUTHORS: Warren McGonnagle, Illinois Institute of Technology Research Institute, Chicago, Illinois and Ford Park, International Science and Technology, New York, New York

SOURCE: Materials Evaluation (formerly Nondestructive Testing), vol. 22, pp. 561-574, December, 1964

This paper was covered by Abstract and Review Serial Number 1644.
##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Changes in the influence of atmospheric humidity during fatigue of an aluminum alloy

AUTHOR: John A. Bennett

SOURCE: Journal of Research of the National Bureau of Standards--C. Engineering and Instrumentation, vol. 68C, pp. 91-100, April-June, 1964

PURPOSE: To report on the influence of water vapor on the fatigue behavior of 6061-T6 aluminum alloy.

ABSTRACT: The fatigue strength of 6061-T6 aluminum alloy specimens was found to be about 14 percent higher in a dry atmosphere than in a moist one. A series of experiments in which the humidity was changed after various numbers of cycles indicated that there was an initial period during which the presence of water vapor had no effect on the total fatigue life. After this initial period, cracks developed and propagated much more rapidly in a moist atmosphere than in a dry one. The change in sensitivity to the environment is believed to result from rupture of the oxide film when the plastic strain becomes locally concentrated.

Results of reversed bending fatigue tests on specimens of 6061-T6 aluminum alloy appear to justify the following conclusions:

1. The fatigue life in an environment of about 5 percent relative humidity was two to three times as long as that in high humidity. This difference corresponds to a difference in stress amplitude of about 14 percent throughout the range investigated.
2. The effect of humidity on the number of cycles to failure was much more pronounced during the latter part of the test than during the initial portion.
3. The data are consistent with the view that there was an initial period during which the humidity had no effect on the fatigue behavior of this alloy.
4. The portion of the test during which the humidity had no effect was significantly shorter than the number of cycles required to form a detectable crack in a low humidity environment. In a moist atmosphere cracks apparently developed very soon after this initial period.
5. At a stress amplitude of 38 ksi, the mean life of specimens containing a small fatigue crack, tested in a dry environment, was greater than the total life of specimens tested in a moist atmosphere.
6. Gas evolution under pressure-sensitive tape was observed only after visible fatigue cracks were present.
7. The development of bubbles under transparent tape provided a convenient and sensitive method of detecting small cracks.

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8. No gas evolution was observed when the test was conducted in a low-humidity environment.
9. The extent of shear plane cracking increased with increasing stress amplitude and with decreasing humidity.
10. The results seem to be consistent with the view that during the early part of the fatigue process the deformation is fairly uniform, so that the local strain is nowhere sufficient to break the oxide film. As stressing proceeds, the deformation becomes localized, breaking the film so that the fresh metal surface is exposed to the environment.
11. The striations on some of the fracture surfaces were sufficiently pronounced to produce bright colors by diffraction.

There does not appear to be any reason to believe that the results of this investigation are unique to the alloy investigated; it is probable that they are typical of age-hardened aluminum alloys in general. (Author)

REVIEW: This series of experiments is of less importance to designers than to those interested in exploring the fundamental nature of fatigue. In the latter area, the work is of great interest.
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Serial Number 1844
ASQC Code 775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Navy sees promise in infrared thermography for solid case checking

AUTHOR: William S. Beller, Senior Editor, Engineering

SOURCE: missiles and rockets, vol. 16, January 4, 1965, pp. 22-23

PURPOSE: To describe a promising new method of non-destructive testing.

ABSTRACT: As a result of tests which the Navy has been running on the Polaris A-3 motor case, there is considerable optimism about infrared (IR) thermography for checking out solid-rocket motor cases. Other potential applications of the technique include the non-destructive testing of printed-circuit boards, jet engine and helicopter blades, and such consumer items as truck and refrigerator panels. The Navy has about a year to go in a two-year program to see what IR thermography has to offer.

For rocket motor cases, IR thermography can be used to pinpoint voids caused by defects such as faulty bonds, delaminations, and other defects which give rise to thermal discontinuities. It can detect these conditions relatively easily and quickly. The entire case is carried into a warming room and brought to a few degrees above ambient temperature. Upon removal from the warming room, the case begins to cool by losing heat from the surface, both by radiation and convection. The technique involves measuring surface temperatures to discover any inhomogeneity in the heat flow. The camera system contains an IR sensor which scans the surface of the target by a mechanical means. The IR picture is reconstituted and laid down on Polaroid film for convenience. By constrast with X-ray analysis, it is unnecessary to use a film of the same size as the object under test. However, IR thermography can only supplement, not replace, the X-ray method of non-destructive testing. The advantages of IR thermography include the following: it is non-hazardous to personnel and sensitive devices, it can detect such things as delaminations and voids in a filament-wound case more easily and quickly than the X-ray can, it is relatively inexpensive, and it can be used to make surface temperature measurements on inaccessible targets, or targets which are too fragile or hazardous to touch. It has the disadvantage of being unable to detect radial cracks on a cylindrical specimen.

REVIEW: This is a good brief description of the IR thermograph and its potential uses. As such, it will be of value to those who wish to be aware of the latest developments in non-destructive testing techniques. No doubt additional details may be obtained from the two men who were interviewed in preparing the article. ##

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Serial Number 1845 -1
ASQC Codes 833;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Tantalum capacitor accelerated life testing

AUTHOR: George H. Didinger, Jr., Technical Director, Kemet Department, Linde Division, Union Carbide Corporation

SOURCE: Evaluation Engineering, vol. 3, September/October, 1964, pp. 6-8, 10 and November/December, 1964, pp. 14-16, 18

PURPOSE: To describe the behavior of tantalum capacitors.

ABSTRACT: The hazard rate of solid tantalum capacitors decreases with time. The failure distribution is Weibull with a shape factor less than one. It has been shown experimentally that true-acceleration factors exist for these capacitors (that is, all the capacitors are in the state in which they would have been under other conditions if the time were changed appropriately). The acceleration factors are extremely sensitive to voltage; i.e., increasing the voltage by a factor of two multiplies the acceleration factor by 10^6. Going from $85^\circ C$ to $125^\circ C$ multiplies the acceleration factor by 10^2. The hazard rate decreases appreciably with time so that the survivors of an aging program have a lower hazard rate than the initial batch. Thus one can specify and get any hazard rate for capacitors that is economically feasible. The hazard rate drops by a factor of about 8 for each factor of 10 in time. Accelerated aging is usually used.

The drift characteristics of these capacitors are such that variations in capacitance and power factor are usually negligible and the leakage current decreases with time. The mechanism of failure is a momentary "short". If the current is limited enough (few amperes) the defect may heal; otherwise the failure may become catastrophic.

In calculating acceleration factors, many 1000-hour tests at various temperatures and voltages have been run in "matrix" testing--usually at acceleration factors greater than one. If the factor is too high, the acceleration is no longer true and all aging is kept below this limit. Some testing is being done at factors less than one.

The failure mechanism is caused by defect centers in the tantalum anode which migrate to the anode-dielectric interface where they cause the current spikes.

REVIEW: The capacitors are quite well behaved; there seems to be negligible scatter in the data and the acceleration is true up to factors of 10^6. Few other components have such remarkable behavior. The

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

Weibull formulas in the paper both contain misprints and should not be used. The discussion on statistics is questionable in some places, as for example when it is stated that confidence statements are out of place when the whole batch is tested. Since some scatter in the data is predicted according to the Weibull formula, there must be uncertainties in any statistic calculated from the data. The term "capacitor-hours" when used for a Weibull distribution to indicate the amount of testing is meaningless since an hour near time zero has a much different effect than at time 100 hr (say). The statement that "... a small group of 10,000 pieces was put on test ..." indicates the large amount of testing done in this program. Some capacitors have been tested for about seven years. On cumulative probability plots the conventional least squares analysis is not valid since the data are highly correlated. Each data point on Weibull paper is also not likely to have the same weight. ##

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Serial Number 1846
ASQC Code 833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Comments on the Evaluation Engineering connector report

AUTHOR: James E. Atkinson, General Manager, Amphenol-Microelectronics, Amphenol-Borg Electronics Corporation

SOURCE: Evaluation Engineering, vol. 3, November/December, 1964, pp. 20, 22

PURPOSE: To reply to a connector report and provide additional information on Amphenol's position.

ABSTRACT: Some of the comments in the connector report (see Abstract and Review Serial Number 1681) do not accurately describe Amphenol's position. The correct position can be summarized as follows:

1. Amphenol is heartily in favor of the EIA Guidelines insofar as they suggest that a life cycle be made up based on actual use applications that a connector would be subjected to in the field.

2. Amphenol most definitely subscribes to the basic strength concepts contained within the guidelines so that a design engineer can know how good a connector is rather than just that it will pass a specific level of stress.

3. Amphenol recommends the use of a per cycle failure rate based on industry acceptance and reasonable cost of such a program.

4. Amphenol believes that the government has a very important part to play in connector reliability from the standpoint of auditing all testing so that cheating cannot occur.

REVIEW: The connector controversy is quite lively, involving, as it does, two large companies (Amphenol and Cannon) on opposite sides of the fence. The controversies involve testing, rating, and types of connectors. About the only fair comment on the above is that it is apparently intended to provide an official Amphenol position on some of the testing and rating aspects of connectors.
##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: How to report the status of reliability programs

AUTHOR: Marvin H. Walker, Jr., Quality Engineering, Electro-Mechanical Research, Inc., Sarasota, Florida

SOURCE: Evaluation Engineering, vol. 3, November/December, 1964, pp. 30-31

PURPOSE: To illustrate a standard periodic reporting procedure for the status of reliability programs.

ABSTRACT: A standard reliability report format for subcontractors has been developed and used on a major system. These reliability status reports include:

1. Summary Sheet
2. Discussion of task activities in Summary Sheet
3. Significant incidents
4. Test results
5. Summary of failure reports, failure analyses, and corrective action.
6. Reliability Growth Curve.

The task of preparing the reports by the subcontractor is simplified by foreknowledge of what is needed, and the contractor's efficiency is improved in evaluating the reports from a group of subcontractors. Experience has indicated that the number of monitoring trips formerly required can be reduced without any sacrifice of control.

REVIEW: The subject of this brief paper seems very simple. However, it exemplifies the specific requirement which the buyer of a reliability program often does not state, ultimately leading to confusion and inefficiency in the buyer-seller relationship. More specific requirements such as this are needed to further remove the vagueness from reliability programs. A remark on the desire for brevity in the reliability program status report is also appropriate. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Watch out for inherent errors in mathematical computations

AUTHOR: Irving Belson, IBM General Products Division

SOURCE: Evaluation Engineering, vol. 3, November/December, 1964, pp. 32-33

PURPOSE: To show how errors are propagated through arithmetical operations.

ABSTRACT: In addition or subtraction, the numerical (or absolute) errors are added (in absolute value). In multiplication or division, the relative (or fractional) errors are added (in absolute value).

REVIEW: The use of the term "error" is quite common in the sense used by the author, but it can be quite misleading also. If in fact the true error is known, there is no problem because the corrected value can easily be ascertained and the formulas given in the text have no meaning. If, on the other hand, the answers are uncertain by an indicated amount, the method of combining uncertainties depends on what kind they are. If the uncertainties are the maximum allowable, then the text is correct. If, on the other hand, they are the standard deviation, the text is incorrect and they add as "the square root of the sum of the squares."

As mentioned in the review of the author's previous paper (see Abstract and Review Serial Number 1679), most engineers are aware of the techniques for propagating errors through a distribution. If the variables are all assumed to be uncorrelated and $Z = f(x_1, x_2, \ldots x_n)$, the variation in Z due to a variation in x_i is $(\Delta Z)_i = (\partial f/\partial x_i)\, \Delta x_i + o(\overline{\Delta x}_i^2)$. These are combined as indicated in the review mentioned above, depending on exactly what is meant by the Δx_i. If the variables are correlated (i.e., a particular value of one gives some idea of the value of the other), or if the uncertainties are measured by estimates of the standard deviation, then the situation is more complicated.

The elaborate treatment given in the text for the simple cases treated is appropriate to a very elementary tutorial approach. See also Review Serial Number 1909. ##

Serial Number 1849
ASQC Codes 802;812

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability training with tape

AUTHOR: G. H. Beckhart, Manager, Engineering Product Assurance, Radio Corporation of America

SOURCE: Evaluation Engineering, vol. 3, November/December, 1964, pp. 34-35

PURPOSE: To describe the recorded material available for reliability training conferences.

ABSTRACT: In 1963, at the Reliability Training Conference held at Albuquerque, the oral presentations were recorded on tape. These were painstakingly edited and "annotated". Supplementary text was printed. These have had enthusiastic reception where they have been used.

The tapes and visual material are available with a money-back guarantee. Further information and price lists may be obtained by writing to Gordon H. Beckhart, Chairman, Reliability Training Conference, 1019 Sycamore Street, Haddon Heights, New Jersey or the Reliability Training Conference, c/o American Society for Quality Control Headquarters, 6197 Plankinton Building, 161 W. Wisconsin Avenue, Milwaukee 3, Wisconsin.

REVIEW: This is a brief background for the tapes and text. The essential material is given in the abstract above.

The author, in a private communication, has advised that a tape on Military Handbook 217 is now undergoing test and will soon be available. ##

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Serial Number 1850
ASQC Codes 831;832

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Inspection and testing as a problem in man-machine systems control engineering

AUTHOR: Howard A. Thompson, Systems Control Consultant, Princeton, New Jersey and Edward A. Reynolds, Quality Control Consultant, Ligonier, Pennsylvania

SOURCE: Industrial Quality Control, vol. 21, pp. 21-23, July, 1964

PURPOSE: To provide an introduction to man-machine systems engineering, with a check list for application of systems principles to quality control engineering.

ABSTRACT: Systems engineering is the coordination of technological advances in many varied sciences--physical and behaviorial--into an operable combination to improve human production of useful items, energy or information. It looks, not at the individual sub-part, but rather at the function and design of the overall structure. In systems control engineering we must be careful to assign to man those things he can do best, to machine what it can best do, and we must, therefore, have an understanding of the current abilities and limitations of each. We may classify what a machine can do best as man's lower intellectual activities and what man can do best as his higher intellectual activities. A tabulation of these characteristics is presented.

The control of the larger, more complex systems of the future will be too much for either man or machine alone to manage. There will be a need for the combined output of the intellect of man, the alert sensing of instrumentation, and the speed and memory of the modern computer, all engineered into one man-machine system. The design of effective man-machine systems will require the combined efforts of a wide range of disciplines. A check list is provided for the use of the inspection or test manager who may wish to consider his control problems in a systems-engineering light. (Authors in part)

REVIEW: This is a good introductory paper on man-machine systems engineering which should be of interest to the novice in this field. It does not go into the details of the application of systems and human engineering, but five references are cited for the information of those who wish to delve deeper. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Some reliability problems in the chemical industry

AUTHORS: H. Smith and S. D. Dubey, The Procter and Gamble Company, Cincinnati, Ohio

SOURCE: Industrial Quality Control, vol. 21, pp. 64-70, August, 1964

PURPOSE: To discuss three problems in the chemical industry which are closely related to the kinds of problems discussed in the reliability literature.

ABSTRACT: The first part of this paper is concerned with two consumer-oriented chemical problems classified as "decay curve fitting" problems. The analogy between this type of problem and the classical reliability problems shown in the engineering reliability literature is indicated. The two problems differ in that the first one (percent Available Chlorine) is treated by the usual regression model technique, while the second problem (odor retention) is treated as a "simple stochastic process" using the method of maximum likelihood. In each case mathematical models are determined and the parameters are estimated. The practical usefulness of the resultant mathematical models is discussed, and some comments are made about the use of "eyeballing" techniques in these kinds of problems.

The second part of the paper treats a problem involving a proposed change in a particular plant operation. The problem reduces to the classical test of significance procedures for reliability-type information. The distribution involved is a two-parameter Weibull.

REVIEW: The problems described in this paper will be of interest to reliability analysts to the extent that they represent approaches which can be applied to other situations. The methods used (linear regression, maximum likelihood, and significance testing) are in themselves quite well known procedures. ##

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Serial Number 1852
ASQC Codes 510;823

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An interpretation of truncated sequential life tests

AUTHORS: H. Ginsburg* and D. H. Shaffer, Department of Mathematics, Westinghouse Research Laboratories, Pittsburgh, Pennsylvania
*(Now at Bettis Atomic Power Laboratory, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania)

SOURCE: Industrial Quality Control, vol. 21, pp. 186-191, October, 1964

PURPOSE: To present methods for extracting meaningful information from sequential life-test procedures when the test has been stopped before a decision has been reached.

ABSTRACT: Sequential life-test procedures possess an average efficiency which is greater than that for non-sequential procedures. However, life-test programs must sometimes be prematurely terminated. This article offers methods for extracting meaningful information from the test data already obtained by the time the test had to be stopped. Approaches using the likelihood function and prior knowledge are given.

An exponential distribution of time-to-failure is assumed. The nature of sequential tests and the circumstances under which they may have to be terminated prematurely are discussed. The problem is illustrated through a numerical example. Solutions based on the likelihood function are outlined. An approach for use when a prior distribution of mean life can be assumed is described and illustrated. The difficulty of determining an appropriate prior distribution is recognized. (Authors in part)

REVIEW: This is a well-written paper addressed to a subject of practical importance. The authors do not claim to have all the answers, but they do focus attention on a meaningful and useful interpretation of the situation in which a sequential test has had to be terminated before a decision was reached in the prescribed way. The use of prior information in reliability analysis is a subject of considerable interest. There are very few situations in which a manufacturer of an item does not have some idea as to its reliability before final testing is done. The big question, and the one which hampers the use of Bayesian inference, is that of having reasonable assurance of the existence of a particular prior distribution. It is a question well worth more attention than it has received, and a paper such as this serves a useful purpose in calling attention to it. ##

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Serial Number 1853
ASQC Code 843

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability data processing and reporting in industry

AUTHOR: Irvin R. Whiteman, Computer Concepts, Inc., Los Angeles, California

SOURCE: Industrial Quality Control, vol. 21, pp. 305-309, December 1964

PURPOSE: To describe the role of the computer in the various problem areas of reliability and quality control.

ABSTRACT: Every aspect of reliability and quality control has felt the impact of the computer. Data retrieval, reliability prediction and data acquisition are now being accomplished at rates which but one-half decade ago were idle contemplations.

Continual product development and improvement coupled with new and better information from historical files and actual tests perpetuate the necessity for prediction. Monte Carlo, Parameter Variation, Worst-Case and Moment methods are available for this analysis.

In the future, technical groups such as the American Society for Quality Control must play a more active and effective role with respect to the computer. A cooperative effort would result in better dissemination of information and programs of interest to our quality control community. (Author)

REVIEW: This is a well-written paper which does a good job of describing the various ways in which the electronic computer can serve the interests and needs of the reliability/quality control community. While most reliability engineers will be familiar with some of the ideas presented, they should find the paper worthy of their thoughtful attention. ##

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65A13055

Serial Number 1854
ASQC Codes 220;222;823;
850

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Some comments on truncated sequential life tests for the exponential distribution

AUTHOR: Leo A. Aroian, Space Technology Laboratories, Inc., Redondo Beach, California

SOURCE: Industrial Quality Control, vol. 21, pp. 309-312, December, 1964

PURPOSE: To clarify the matter of truncated sequential life tests for the exponential distribution.

ABSTRACT: In a recent article (see Abstract and Review Serial Number 1455) upper and lower sequential chart limits at various confidence levels are given by using what amounts to approximate probability limits of the Poisson distribution. The article advocates using these limits for reliability life testing. The method is based on an analogy with upper and lower quality control limits used in the control of a manufacturing process. In plotting points on a quality control chart, each sample point is independent of every other sample point. But this is not true in sequential life testing. Each point in the sequential life test depends on the previous point. An investigation of the consequences of using the proposed method shows in detail why the proposed method is incorrect.

The acceptance and rejection boundaries for the correct sequential test are given and explained. Pertinent references are cited, including those which give tables for use in performing exact truncated sequential life tests based on the exponential distribution. (Author in part)

REVIEW: The paper covered by Abstract and Review Serial Number 1455 contained a serious error, as was pointed out in the REVIEW. That paper stimulated this one, which provides a correction, explains in detail the nature and consequences of the error, and describes the correct procedure. It is an excellent expository treatment of truncated sequential life tests for the exponential distribution. As such, it should be of interest and value to all who run such tests.

In the same issue of Industrial Quality Control (p. 290) there is a letter to the editor which also points out the error mentioned above. ##

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3/65

65A13056

Serial Number 1855
ASQC Codes 223;823

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Graphic sampling plans for consumer acceptance of electronic components

AUTHOR: L. Danziger, IBM Corporation, Poughkeepsie, New York

SOURCE: Industrial Quality Control, vol. 21, pp. 312-317, December, 1964

PURPOSE: To expand existing non-replacement sampling plans, present them in graphical form, and compare them to replacement plans.

ABSTRACT: Sampling plans have previously been derived for testing a minimum mean life with a guaranteed consumer protection. These non-replacement plans are examined in a different light, expanded, graphed, and compared to replacement plans. A table is derived for quickly approximating the operating characteristic curve for any choice of consumer-oriented plan, thus enabling one to evaluate the protection that the plan affords the producer. All of the plans are based on the assumption that the distribution of times-to-failure is exponential. (Author)

REVIEW: This is a clear and concise paper which makes a useful contribution to the literature on sampling plans. Pertinent references which form the background for the work are cited, and the procedures used by the author are adequately described. ##

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Serial Number 1856
ASQC Codes 520

552;822

222;433

831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

64A20072

TITLE: Statistical design and analysis of qualification test program for a small rocket engine

AUTHORS: S. Roy Wood and Donald E. Hartvigsen, Aerojet-General Corporation, Azusa, California

SOURCE: Industrial Quality Control, vol. 20, June, 1964, pp. 14-17

This is the complete version of the paper a condensation of which was covered by Abstract and Review Serial Number 1018.

G

TITLE: Practical applications of the Weibull distribution

AUTHOR: J. N. Berrettoni, Department of Statistics, Western Reserve University

SOURCE: Industrial Quality Control, vol. 21, pp. 71-79, August, 1964

This paper was published in the Transactions of the Sixteenth Annual ASQC Convention, May, 1962 and was covered by Abstract and Review Serial Number 751.

64A24510

TITLE: Bayesian operating characteristic curves for reliability and quality sampling plans

AUTHOR: R. E. Schafer, Hughes Aircraft Company, Fullerton, California

SOURCE: Industrial Quality Control, vol. 21, pp. 118-122, September, 1964

This paper is the same as the one covered by Abstract and Review Serial Number 1287.

65A10093

TITLE: System reliability when failure depends on a parameter that ages

AUTHOR: F. R. Van Wagner, Staff Programmer, IBM, General Products Division, Development Laboratory, San Jose, California

SOURCE: Industrial Quality Control, vol. 21, pp. 253-258, November, 1964

This is the complete paper referred to in Review Serial Number 1019. ##

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 65N81134 Serial Number 1857
ASQC Codes 553;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: MTBF Tables

AUTHOR: (Prepared by Myron A. Wilson, Senior Reliability Engineer, Burroughs Corporation, Burroughs Laboratories, Box 305, Paoli, Pennsylvania)

SOURCE: Burroughs Corporation, Military Systems Division, Burroughs Laboratories, Box 305, Paoli, Pennsylvania, 219 pp., 15 January 1963

PURPOSE: To provide tables for estimating the MTBF (of an exponential distribution) from test data for given confidence levels.

ABSTRACT: Assuming that reliability is given by R = exp(- time/MTBF) and that a series of tests has been run, MTBF can be estimated from the test data. These data will be T (the cumulated successful time of all elements on test) and r (the number of failures). The test may have been run for a fixed time T or for a fixed r. In either event, bounds may be calculated for MTBF for given confidence levels. The percentage confidence levels used are 2.5, 5, 10, 25, 50, 75, 90, 95, 97.5, and 99 for both upper and lower confidence bounds; $1 \leq T \leq 1000$ and $0,1 \leq r \leq 21, 22$.

REVIEW: These tables may well be useful to those who must make exact calculations of MTBF--given the usual assumptions. The range of T is sufficient since the units are quite arbitrary (MTBF and T will have the same units). The range for r is more than sufficient since r will not exceed 10 to 15 in practical situations of reasonably high reliability.

The introduction to the tables is adequate (although the examples were not checked in detail) except for one point. When r is the random variable and MTBF is to be estimated, the confidence levels are not exact as implied. The confidence statements are of the form "the confidence is at least ..." or "the confidence is at most ..." depending on the appropriate circumstances. The exact statements are given in Review Serial Number 783. When T is the random variable, there is no such problem.

(A minor point concerns the covering letter accompanying the book. The statement is made "...These tables are based on the chi-square approximation ..." This is not an approximation but an exact identity.)

In the introduction T/r is said to be the best estimate of MTBF (best is also defined there). This is true only when T is the random variable (and r of course ≥ 1). If r is the random variable, a unique best estimate, in the stated senses, may not exist. ##

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9

Serial Number 1858
ASQC Codes 864;874

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability criteria in radio relay systems

AUTHORS: C. A. Lewis and M. Telford, The Marconi Company Limited, Marconi House, Chelmsford, Essex, England

SOURCE: Point to Point Telecommunications, vol. 7, June, 1963, pp. 30-43 (Published by the Communications Division, Marconi's Wireless Telegraph Company Limited, Chelmsford, England)

PURPOSE: To discuss the general factors affecting the reliability of a wide-band radio relay system.

ABSTRACT: A major component of telecommunications networks is the wide-band radio relay system, carrying up to 1800 high quality telephone channels, or television, over long distances. The three basic causes of traffic outage on such systems are: (a) Loss of received signal (b) Equipment failure (c) Power supply failure.

Loss of received signal is due largely to adverse propagation conditions, although a secondary cause may be lack of rigidity in the antenna support structures. By proper care in system design and planning, the outage time due to these causes can be kept low.

Well designed equipment, carefully maintained, will obviously result in a low equipment failure rate. The time that elapses between the occurrence of a fault and restoration of the system to normal is determined by various factors. Unless reasonable care is taken to control these, delay in restoration may be the largest single element in total outage time.

Outage caused by power failure is dependent on the reliability of the primary source of power and the efficiency of the standby facilities. These basic causes are considered in more detail, so that conclusions may be reached on the overall requirement. (Authors in part)

REVIEW: This is a general article with no specific information for designers. It is, however, informative for those who do not care for, or need, a detailed accounting. ##

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Serial Number 1859
ASQC Codes 711;716

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Transformer life evaluation

AUTHOR: Paul Mann, University of Idaho, Moscow, Idaho

SOURCE: 7 pp., presented at the IEEE Electro-Nuclear Conference, Richland, Washington, April 20-30, 1963, IEEE Conference Paper No. CP63-703, available from IEEE, Post Office Box A, Lenox Hill Station, New York, New York 10021

PURPOSE: To discuss the changes in deterioration rate of transformers due to changing their loading.

ABSTRACT: Evaluation of transformer life in reliability and economic studies involves a changing life expectancy and failure rate. The relation of loading to temperature and insulation life is reasonably defined. The problem is to establish means of assigning values to added transformer life or reduced failure rates.

A user can predict the return on transformer investment and the reduction in failure rates by use of relative aging and failure probability curves applied to the present age of existing installations.

The analysis presents a method of attack on the problem of insulation life value. It also makes clear some areas where more information would be useful.

(1) Do any field records exist which would support the assumed preservation of older units by modest load levels?

(2) What is the actual non-thermal life of insulation? The constant application of voltage plus the occurrence of the previously mentioned unusual stresses perhaps impose some practical limit.

Most present transformers exceed the assumed twenty year normal life because their actual loading has been below rating for long periods. Returns look reasonably attractive for load reductions on those transformers which have been used at load levels near their ratings. (Author in part)

REVIEW: The approach to the problem seems reasonable, although the details of the calculations are not made clear. Few of the assertions about behavior of remaining life vs. loading are analyzed in the paper. The paper does, however, represent a valid means of looking at the problem. For another paper on the life expectancy of transformers see Abstract and Review Serial Number 1926. ##

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Serial Number 1860
ASQC Codes 770;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Evaluation of the cause of overload failure in rotating equipment

AUTHOR: Donald H. DeVries, Anaconda Wire and Cable Company, Muskegon, Michigan

SOURCE: 2 pp., presented at the 5th Electrical Insulation Conference, Chicago, Illinois, September, 1963

PURPOSE: To find the failure temperatures of wire insulators in overloaded armatures and to find a test which rates the insulations in the same order.

ABSTRACT: Overloads are a major cause of failure with wound-armature rotating equipment. The reasons for this are:

1. Rotating equipment, because of the nature of its applications, is often subjected to mechanical or electrical overloads and thus overheating.
2. The insulation system in a wound armature is subject to large centrifugal forces due to high rotational speeds and/or large diameters.

This combination of high temperatures and large forces can result in premature failure of the equipment. Often the deciding factor which determines whether a motor or generator endures or fails the overload is the type of magnet wire in the armature.

The results of the overloaded generator tests are consistent with field experience with wound-armature equipment. Nylon or nylon combination magnet wires have an excellent reputation in these applications. The significant point of these tests is the determination of the temperature at which the armatures failed. This information is necessary in the analysis of the mechanism of failure.

The Compression Flow Test can be used to obtain the softening curve of a wire enamel as a function of temperature. This curve, together with the armature failure temperature can be used to explain why certain wire enamels perform better than others under overload conditions. If the softening curves were a straight line function of temperature, a simple test such as the "Thermoplastic Flow Test" could be used to completely analyse the performance of a magnet wire under overload conditions. As these curves are not straight lines but in fact cross at certain temperatures, it is necessary to know the temperature at which failure occurs to explain or predict the cause of failure. (Author)

REVIEW: Interestingly enough, the failures of the wire insulation are not due to the field in the dielectric, but are due to mechanical displacement of the insulation by the large forces involved. The purpose of the paper seems to have been well accomplished. ##

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Serial Number 1861
ASQC Code 833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Improved reliability for vehicular communications equipment

AUTHOR: T. A. Watson, Canadian Marconi Company, 2442 Trenton Avenue, Montreal 16, Canada

SOURCE: IEEE Transactions on Vehicular Communications, vol. VC-12, September, 1963, pp. 28-31

PURPOSE: To describe the design of a higher-reliability vehicular transmitter/receiver.

ABSTRACT: At the time of development of the first units described (1955), long transistor life was not being realized. A telephone code selector unit was redesigned from relays to cold-cathode trigger tubes with a big improvement in serviceability and life. At the design stage in the communications equipment, transistors were not too useful at 150 Mc and consequently were used only in DC and audio circuits. Long-life tubes (10,000 hr guaranteed) were used in other places. The tube failure rate per set dropped from 3.3%/1000 hr to 0.11%/1000 hr. Careful attention to heat generation and removal also helped to improve the life of the set. Filament voltage regulation was of prime importance in achieving long tube life.

REVIEW: This is a brief description of some of the engineering design compromises and approaches used for commercial radio equipment. It may be of value to design engineers who have similar decisions to make. (No detailed circuits are given.) ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Apollo System reliability and safety estimating procedures

AUTHOR: D. J. Young, NASA (MIR), Washington 25, D. C.

SOURCE: 21 pp., presented at a meeting of the New York Metropolitan Chapter, PGR, IEEE, April 15, 1963

PURPOSE: To describe the estimating procedures for safety and reliability of the Apollo System.

ABSTRACT: The Apollo System for Lunar Orbital Rendezvous is quite complex. There are about 600 pieces of equipment and 12 major time phases. Mission success is the safe return of the three astronauts from the completed lunar landing; crew safety is the same criterion except that the lunar landing need not have been completed. The calculations for each are made by breaking the system into blocks for each time phase and assigning reliabilities to each. There are several possible paths through the logic diagram of the system for either mission success or crew safety. A Monte Carlo method is used to calculate success and safety. In each time period other than the first, the probabilities of success for each block are conditioned on not having failed in an earlier time phase.

The programs are being improved so that incorporation of changes is easier and so that degradation of equipment can be accounted for.

REVIEW: This is a clear and concise discussion of the principles involved in the reliability analyses. A few details are given for most phases, so that the complexity of the situation can be appreciated. This is not a detailed description of the procedures and computer programs--as befits an oral presentation. ##

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Serial Number 1863
ASQC Codes 711;714;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The reliability aspects of liquid sterilant use

AUTHOR: Sidney Wiener, Head, Chemical Technology Section, Materials Technology Department, Hughes Aircraft Company, Culver City, California

SOURCE: 18 pp., presented at a joint meeting of the Professional Groups on Component Parts and Reliability and Quality Control of the Los Angeles Section, IEEE, Los Angeles, California, June 17, 1963

PURPOSE: To present results of studies on liquid sterilants and their effects on materials used in spacecraft.

ABSTRACT: There are two problems in sterilizing a space vehicle:

1. What fraction of the organisms are killed? (hopefully, very large).
2. What was the effect on the spacecraft reliability? (hopefully, very small).

The sterilizing properties of two types of solutions were studied: formaldehyde in anhydrous methanol and formaldehyde in distilled water. The techniques of applying the spores, exposing them to sterilant conditions and recovering the spore samples are described along with some of the experimental difficulties. The water-formaldehyde solutions appeared to be the more effective, and showed no deterioration after aging for 4 months.

Due to time limitations, only methanol-formaldhyde was tested for compatibility on the materials. Most were unaffected. Viton A was seriously damaged and some connectors exhibited poor insulation properties while wet. (These are described in more detail.)

REVIEW: This is a subject which is little discussed in the reliability literature, yet does create problems for design engineers. This paper gives a good idea of some of the experimental problems for the liquid sterilants and a few results on their effects on materials. ##

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3/65

65A23783

Serial Number 1864
ASQC Code 844

RELIABILITY ABSTRACTS
AND TECHNICAL REVIEWS

TITLE: Excerpts from 'Second thoughts on reliability'

AUTHOR: G. A. Raymond, UNIVAC Division, Sperry Rand Corporation, St. Paul, Minnesota

SOURCE: Electrical Design News, vol. 9, November, 1964, pp. 66-72

This article consists of paraphrases and excerpts from the paper "Second thoughts on reliability," which was presented at the International Aerospace Conference in Phoenix, Arizona on April 23, 1964. The main points are essentially the same as those in the paper covered by Abstract and Review Serial Number 1641. ##

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63N14851

Serial Number 1865
ASQC Codes 821;838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Probability theory as applied to reliable network design

AUTHOR: James D. LaRue, Directorate of Advanced Systems Planning, Aeronautical Systems Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio

SOURCE: Technical Documentary Report No. ASD-TDR-62-1072, 37 pp., February, 1963 (DDC AD No. 400560; NASA accession number N63-14851)

PRUPOSE: To derive probability-of-success equations for redundant networks from basic component failure statistics, and to calculate the reliability of a network designed on the basis of the results.

ABSTRACT: The author presents definitions and typical failure and survival curves--the normal and exponential curves. Examples of the two distributions are given, using a ground-based radar, the AN/FPS-3, and a 2D21W vacuum tube, etc. Equations relating the variables are derived.

The significance of these reliability techniques is considered as it affects engineering design. Probability-of-success equations are discussed in considerable detail for various simple redundant networks. The two basic quad networks (four blocks in parallel-series or series-parallel) are analyzed, and compared to parallel redundancy. This is done using failure data on several types of components. Equations are presented which can be used to evaluate circuit reliability.

Results are presented graphically. The conclusion is that redundancy should proceed stepwise, with periodic calculations governing the feasibility of doing further work. Suggested areas for future investigation and a bibliography are included.

REVIEW: This paper is rather too long and involved to be readily useful; in this respect it reflects its origin as a Master's Thesis. Much that is useful is presented, however. It should appeal to two audiences--the reader wishing to learn more about reliability calculations, and the practicing engineer wishing to use its conclusions. To be truly valuable to the latter it should have been reduced to about one fifth its present length. ##

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65A14391

Serial Number 1866
ASQC Codes 612;831;838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability simulation model

AUTHORS: B. H. Hershkowitz, M. E. Wheelock, and D. P. Maher, North American Aviation, Inc., Space and Information Systems Division, Downey, California

SOURCE: 15 pp., presented at the Fourth Annual Seminar on Reliability in Space Vehicles sponsored by PTGR, PTGED, and PTCP of the Los Angeles Section, IEEE, December 6, 1963 (first paper in Proceedings available from Western Periodicals Company, 13000 Raymer Street, North Hollywood, California, Price: $6.50) 64N28292

This paper is identical to the one covered by Abstract and Review Serial Number 1192. ##

see also 64A15948

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64A14392
64N28293

Serial Number 1867
ASQC Codes 715;830;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: RIFT reliability and maintainability considerations arising from nuclear propulsion

AUTHORS: J. A. Barker, R. A. Blais, W. Hansen, and L. L. Woodward, Nuclear Space Programs, Lockheed Missiles & Space Company, Sunnyvale, California

SOURCE: 12 pp., presented at the Fourth Annual Seminar on Reliability in Space Vehicles sponsored by PTGR, PTGED, and PTCP of the Los Angeles Section, IEEE, December 6, 1963 (second paper in Proceedings available from Western Periodicals Company, 13000 Raymer Street, North Hollywood, California, Price: $6.50)

PURPOSE: To describe considerations concerned with testing the RIFT stage nuclear reactor.

ABSTRACT: The use of a nuclear reactor in the RIFT Stage Test Program is accompanied by the need to consider problems of radioactivity in design, disassembly, modification, and maintenance. Limitations on accessibility and repairability are imposed by radioactivity from hot captive testing. Inherent reliability and its complement, maintainability, are thus constrained by the difficulties of remotely manipulated operations, personnel exposures, and decontamination procedures. The stage itself, the captive test stand, and the stage transporter must all be considered. RIFT Program planning encompasses these considerations. (Authors in part)

REVIEW: This is an abbreviated discussion which, combined with editorial problems (Figure 1, Table I, and some of the text are missing), is somewhat difficult to follow when one is not rather familiar with the program. Otherwise the material provides a rather general insight into the problems involved in the testing. ##

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69A14393
64N28294

Serial Number 1868
ASQC Code 831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: New methods for evaluation of performance reliability

AUTHOR: Dale L. Burrows, Marshall Space Flight Center, Huntsville, Alabama

SOURCE: 10 pp., presented at the Fourth Annual Seminar on Reliability in Space Vehicles sponsored by PTGR, PTGED, and PTCP of the Los Angeles Section, IEEE, December 6, 1963 (third paper in Proceedings available from Western Periodicals Company, 13000 Raymer Street, North Hollywood, California, Price: $6.50)

PURPOSE: To review a problem involving probabilistic mechanical forces.

ABSTRACT: In the design of space vehicles there is a great need for methods to solve complex time-variant performance problems in combination with statistical influences. A simplified version of an in-flight stage separation problem is considered and a simple mathematical model is devised for integrating the performance parameters with their interacting statistical content in such a way as to arrive at the probability of success. Lower stage weight, retro-rocket thrust, lower stage cut-off thrust, and separation distance between stages needed to avoid explosion at upper stage ignition were the assumed controlling parameters.

The primary purpose of the paper was to review the problem and propose a methodology. No meaningful results were obtained because of lack of sensible statistical input. The analysis served to indicate the nature of a broad problem area that is in much need of theoretical treatment. Also there was a strong indication that a better appreciation of the statistical aspects of performance problems is needed in order to upgrade our data-taking and experience-recording practices. (Author)

REVIEW: As the author indicates, this is a rather general paper and serves to illustrate the problem rather than to present its solution. The main difficulty is in knowing the type of uncertainty in the acceleration and how the possible accelerations are correlated as functions of time. Once this problem is solved, the methodology for the rest of the problem is straightforward (although getting the data may well not be so). ##

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64A14384

Serial Number 1869
ASQC Codes 782;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Environmental resistance inherent in equipment

AUTHOR: W. B. Anderson, Space-General Corporation, El Monte, California

SOURCE: 17 pp., presented at the Fourth Annual Seminar on Reliability in Space Vehicles sponsored by PTGR, PTGED, and PTCP of the Los Angeles Section, IEEE, December 6, 1963 (fourth paper in Proceedings available from Western Periodicals Company, 13000 Raymer Street, North Hollywood, California, Price: $6.50)

PURPOSE: To discuss a technique for incorporating the effects of degrading environments into a performance analysis.

ABSTRACT: It is presumed that conventional performance analysis has been carried out so that the mission performance is known as a function of part parameters. It is further assumed that the "complete" environmental profile is known and that the variation of each part parameter due to this profile can be calculated. The mission time is divided into short intervals and the environmental profile calculated for each interval. By propagating the profile through the parameters and the parameters through the performance equations, the mission performance can be calculated for each time interval. While digital or analog computers are usable in principle, only the digital computer currently seems feasible for complex problems. An example is given. This method helps to eliminate some of the heretofore-required safety factors by eliminating some ignorance about system behavior.

This development work (designated ERIE for Environmental Resistance Inherent in Equipment) was sponsored by the Research and Technology Division of the Air Force Systems Command at Wright-Patterson Air Force Base, Dayton, Ohio.

REVIEW: This is an organized methodology for part of the "infinite attention to detail" that is required of systems if their success is to be virtually certain. It shows how available knowledge can be used to solve some difficult engineering problems. The random aspects of the problem are not treated here although they could presumably be handled at least to a certain extent. (Some of the graphs and charts use specialized terms that the general reader may not understand.)

The author, in a private communication, has pointed out that this paper was a preview of a contract report published in January 1964 as the AFSC's Technical Documentary Report RTD-TDR-63-4101, and that its new design adequacy method is specified as mandatory analysis in certain new hardware development contracts and RFP's. Other papers on this program have been covered by Abstracts and Reviews Serial Numbers 1237, 1770, and 1816. ##

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64A14395

Serial Number 1870
ASQC Codes 715;782

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Electrolytic capacitors in space electronic equipment

AUTHOR: Stanley W. Bubriski, Sprague Electric Company, North Adams, Massachusetts

SOURCE: 19 pp., presented at the Fourth Annual Seminar on Reliability in Space Vehicles sponsored by PTGR, PTGED, and PTCP of the Los Angeles Section, IEEE, December 6, 1963 (fifth paper in Proceedings available from Western Periodicals Company, 13000 Raymer Street, North Hollywood, California, Price: $6.50)

PURPOSE: To discuss applications of electrolytic capacitors in space satellite electronic equipment.

ABSTRACT: This paper discusses applications of electrolytic capacitors in space satellite electronic equipment. The data show the effects of high energy radiation and extreme vacuum conditions on both tantalum and aluminum electrolytic capacitors, as well as the effects of severe vibration and shock stresses.

The irradiated capacitors were exposed to gamma radiation from a 10 kilo-Curie cobalt source in dosages of 4.4×10^6 REP (Roentgen Equivalent Physical) and 1.3×10^7 REP. These fairly heavy dosages approach the equivalents of 5 years and 16 years continuous exposure in the Van Allen Belt (1000-3500 statute miles). It is generally conceded that the effects of gamma radiation on materials will cause the same type of damage as the directly-ionizing particles such as electrons and protons. Thus gamma radiation was used in these tests (it is the most convenient kind).

Data on effects of gamma radiation on aluminum and tantalum capacitors indicate that, under dosages of 4.4×10^6 REP, all capacitors tested show excellent stability of electrical parameters. Dosages of 1.3×10^7 REP have no deleterious effects on foil tantalum or aluminum electrolytic capacitors. Capacitors containing TFE-fluorocarbon materials operate satisfactorily after exposure to gamma radiation.

Various tests under vacuum-temperature conditions indicate that electrolytic capacitors with conventional end seals can operate satisfactorily for extended periods of time. Data also indicate that various high stresses of vibration and shock can be tolerated by properly-designed tantalum electrolytic capacitors. (Author in part)

REVIEW: The technical information in this paper will be of interest to designers. No combined vacuum/radiation results are reported. ##

64A14396

3/65

Serial Number 1871
ASQC Codes 782;833

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

TITLE: Component evaluation and selection for the space environment

AUTHOR: L. W. Geary, Hughes Aircraft Company

SOURCE: 18 pp., presented at the Fourth Annual Seminar on Reliability in Space Vehicles sponsored by PTGR, PTGED, and PTCP of the Los Angeles Section, IEEE, December 6, 1963 (sixth paper in Proceedings available from Western Periodicals Company, 13000 Raymer Street, North Hollywood, California, Price: $6.50)

PURPOSE: To summarize the results of a large-scale component-evaluation program.

ABSTRACT: This is a summary report of a large-scale component-evaluation program directed toward providing selection and application criteria for components used in various space-vehicle applications. The environments used were hard vacuum ($\approx 10^{-6}$ torr), thermal shock, mechanical shock and vibration, and combined vacuum-temperature exposure. The parts reported on are semiconductors, mechanical and hardware items, electromechanical devices, resistors and capacitors of many kinds, and quartz crystals. About 15 pages are used to summarize the information.

REVIEW: This report will be of interest to designers because of the general information it summarizes. No radiation exposures were made. The fact that different manufacturers did not all produce the same quality of product will not be news to experienced designers, but it is well to emphasize this fact to newcomers to the field and purchasing departments. ##

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64A14397

Serial Number 1872
ASQC Codes 817;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Component failure effect on systems--an analytic model

AUTHORS: R. L. Parkhill and J. Pauperas, Jr., Missiles and Space Systems Engineering, Douglas Aircraft Company, Inc.

SOURCE: 50 pp., presented at the Fourth Annual Seminar on Reliability in Space Vehicles sponsored by PTGR, PTGED, and PTCP of the Los Angeles Section, IEEE, December 6, 1963 (seventh paper in Proceedings available from Western Periodicals Company, 13000 Raymer Street, North Hollywood, California, Price: $6.50)

PURPOSE: To introduce the concept of "criticality ranking" in addition to reliability.

ABSTRACT: In any system, the failures of some parts in certain ways cause less trouble than do others. All parts are thus to be rated with regard to their contribution to system loss. "Criticality ranking" is a "totem pole" of flight critical items, with each item having an associated relative criticality. The item which contributes more to probability of stage loss than another item will end up with the larger criticality number. The ranking of all items provides a convenient comparison of their contribution toward stage loss. In judging the criticality of an item, i.e., in assessing the contribution toward stage loss, it is necessary to use a consistent set of rules. A worksheet used by DAC Reliability Analysis Section personnel to determine the criticality of an item is shown. This worksheet is divided into two phases: (1) reliability failure effect analysis and (2) selection of critical items and determination of the degree of criticality. To use this worksheet, four major factors must be considered and applicable data entered prior to further mathematical handling:

1. The possible types of modes of failure for the item.
2. The frequency with which the item fails in each of the applicable failure types or modes.
3. The probability of item failure (for all failure types/modes).
4. The stage loss frequency when the particular type or mode of failure occurs.

Specifically, the criticality number is the portion (in units of 10^{-6}) of the inherent item unreliability assignable to all of the applicable failure types or modes of an item which contribute to stage loss. An example is given. (Authors in part)

REVIEW: This is certainly a good system for allocation of improvement effort, which is one of its main purposes. The authors are to be commended for being realistic in regard to the time and money available to projects. This method is applicable in almost any situation where improvement work is possible. ##

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Serial Number 1873
ASQC Code 775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Spray-on plastics pinpoint flaws

AUTHOR: (Editorial Matter)

SOURCE: The Iron Age, vol. 193, April 2, 1964, pp. 56-57

PURPOSE: To describe the advantages of spray-on photoelastic coatings.

ABSTRACT: While photoelastic methods using transparent coatings are well known, they tend to be difficult to use on production parts. The development of easily-sprayed-on coatings makes this type of quality control work much more simple. The coatings show stress concentrations when the part is observed by polarized light when under load. Those flaws not causing undue strains on the surface do not show up. This can be both good and bad, depending on circumstances.

REVIEW: This is a general article but serves to introduce new methods to those who should know about them. Since the plastic thicknes may be highly variable, the process is probably rather qualitative and if the film is thin, it may not be very sensitive. However, it may still serve the useful purpose of only showing up those areas likely to cause serious trouble. More information can undoubtedly be obtained from the plastic supplier mentioned in the article. ##

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Serial Number 1874
ASQC Code 770

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Testing for 100% reliability

AUTHOR: R. H. Eshelman, Machinery Editor

SOURCE: The Iron Age, vol. 193, May 28, 1964, pp. 66-67

PURPOSE: To list some of the testing done by aerospace engineers.

ABSTRACT: Parts must be extensively tested if the space vehicle is to have high reliability. These tests include overstressing, low temperature behavior, leak testing, and vibration.

On completion of a booster assembly, a thorough shakedown check is made. Then, there are 100% tests of all power hook-ups. As the last check, about 75 technical personnel check out the booster's behavior through a master control console. A string of computers, linked to test stations, television sets and hundreds of test instruments, simulate the ignition, lift-off and in-space response of controls and commands. (Author in part)

REVIEW: The subtitles on the article are a bit misleading since they imply that some comparisons with the testing of mass-produced consumer goods (e.g. automobiles) are made, but such is not the case. In general, this article is just for lay interest. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Zero Defects plan declares war

AUTHOR: P. J. Cathey

SOURCE: The Iron Age, vol. 194, October 29, 1964, pp. 116-118

PURPOSE: To point out the problem of poor attitude on the part of workers and what one company is doing about it.

ABSTRACT: Many mistakes are caused by one department or one small group of machines. Engineers make mistakes in planning and this causes many parts to be made wrong. Since many failures are due to people not doing as well as they know how, the challenge many companies face is how to motivate their workers properly. The Zero Defects program encourages every employee to pledge himself to do the best of which he is capable. Constant reminders are to be at hand for all workers. This type of program has had considerable success in many American and some European companies.

REVIEW: While it is generally difficult to evaluate the real effects of motivational programs, and some even disparage them, there is no doubt that if everyone did as well as he now knows how, most of the reliability problems in the Armed Services would disappear as would many in industry and the aerospace field. The Zero Defects program was started by Martin, Orlando and seems to have caught on in management circles. One can only hope it is as successful as its practitioners claim. Some of those who have tried the program report that its effects tend to "fade out" if the promotional effort is relaxed. This would mean that management's effort in keeping workers interested in the program must be set up on a continuing basis. ##

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Serial Number 1876
ASQC Codes 711;714;782

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Electric shield guards aluminum

AUTHOR: (Editorial Matter)

SOURCE: The Iron Age, vol. 194, November 26, 1964, pp. 80-81

PURPOSE: To summarize some tests by the National Bureau of Standards on cathodic protection of aluminum.

ABSTRACT: Externally applied currents have long been used to protect iron and steel from corrosion in underground and aqueous environments. When the same technique is used on aluminum, however, conflicting results are obtained. The corrosion rates of aluminum alloy 6063-T5 were measured under a variety of exposure conditions. The study showed that electric currents can block aluminum corrosion in some acidic environments. However, the same technique may accelerate corrosion in alkaline environments.

The corrosion of metal is essentially an electro-chemical phenomenon. Differences in electric potential develop at the surface of the metal, causing currents to flow through the electrolyte. Thus, metal erodes from anodic surface areas and the hydrogen evolves at cathodic areas. The electrical technique used to prevent corrosion is called cathodic protection.

In the NBS study, the method was applied to specimens in salt water, in acidic and alkaline salt-water solution, and in air-free soils. Results indicated that electric currents increase the alkalinity of the environment. Apparently, in low pH (acidic) environments this phenomenon has a neutralizing effect; however, the increased alkalinity may be harmful in high pH environments. These results are attributed to the amphoteric nature of aluminum, which, unlike many other metals, can be highly reactive to acids and alkalis. The laboratory results together with field experience indicate that a single value of potential cannot be used to protect aluminum alloys in all underground environments. Instead, the existing corrosion potential of an alloy has to be shifted about 0.1 v in an electronegative direction to achieve cathodic protection. Caution must be exercised in extremely alkaline soils. (Author in part)

REVIEW: This is a summary article of the original research and unfortunately does not give the original reference. The text will largely give an appreciation of the problem and its solution; original sources should be consulted for more detail. More information can probably be obtained from the principal investigator: W. J. Schwerdtfeger of the National Bureau of Standards Institute for Materials Research. ##

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63A23893

3/65

Serial Number 1877
ASQC Codes 844;864

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Parts failure rates resulting from an operational reliability program

AUTHOR: Margaret F. Goggin, Eclipse-Pioneer Division, The Bendix Corporation

SOURCE: 6 pp., presented at the National Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, California, September 23-27, 1963, Society of Automotive Engineers paper 744A (summarized in SAE Journal, vol. 71, October, 1963, p. 112)

PURPOSE: To discuss the field failure rates observed on a Bendix Central Air Data Computer and Vertical Scale Systems.

ABSTRACT: This paper presents the parts failure rates which resulted from an operational reliability program conducted on the Central Air Data Computer and Vertical Scale Systems of the F-105D and F-106A and B integrated Instrument System. The rates, in general, compare favorably with those generated as the result of other programs (specifically those cited in EIA Reliability Bulletin #3--see Abstract and Review Serial Number 1248). However, the semiconductor rates are significantly lower than other industry rates. Evidence is presented which indicates that this is primarily due to the 100% incoming inspection procedures employed by Eclipse-Pioneer Division on all semiconductors. (Author in part)

REVIEW: The numerical results presented here are interesting; the paper contains little beyond this. Any comparisons with the EIA Compendium (see ABSTRACT) are bound to be tenuous because of the many qualifications on the data in that document. ##

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Serial Number 1878
ASQC Code 830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Airplane design for reliability

AUTHORS: Kenneth C. Plewes, James L. Copenhaver, and Melvin A. Hiatt, Transport Division, The Boeing Company

SOURCE: 10 pp., presented at the National Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, California, September 23-27, 1963, Society of Automotive Engineers paper 744B

PURPOSE: To discuss methods used in establishing, measuring, and controlling the "on-time" dispatch probability of the Boeing 727 during its design.

ABSTRACT: Dispatch delays experienced by three commercial trunk airlines on 707-120B and 720B fleets through 82,187 departures in 11 months were categorized by ATA systems and individual components. Individual comparison of each 727 system component or subassembly was made with its 707/720 counterpart as to the number of parts per component, duty cycle, design, operating environment, and accessibility. Delay factors were then computed which expressed expected 727 delays as a given decimal fraction of 707/720 delays.

The overall 727 airplane delay factor was found to be 0.43 relative to the 707/720 delays, and the 727 dispatch reliability 98.02%. (Authors in part)

REVIEW: The paper may be of interest to aircraft designers especially in view of the success probabilities actually given, and of general interest as an example of methods for achieving reliability during the design phase. The methods presented are typical of a reasonable engineering approach that seems both workable and likely to succeed. In a private communication the first author has stated that after 10 calendar months of service for the 727's the dispatch reliability is over 97%; 98% (the design goal) appears to be within reach before they have been in service for 12 months. ##

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Serial Number 1879
ASQC Codes 841;845

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Make experience data work for you

AUTHORS: John Burnett and Take Taniguchi, General Dynamics/Astronautics

SOURCE: 7 pp., presented at the National Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, California, September 23-27, 1963, Society of Automotive Engineers paper 744C (summarized in SAE Journal, vol. 71, October, 1963, pp. 98-102)

PURPOSE: To show that failure data are available that are not being properly used and to suggest improvements.

ABSTRACT: The traditional concept that experience data for valid reliability estimates are not now available is challenged. Major problems are discussed, both technical and administrative, which are associated with marshalling and exploiting a company's past experience to produce knowledge which will lead to more reliable designs, and several solutions are presented. The importance of mutual understanding by designer and reliability specialist coupled with objective attention to details in a simple approach is stressed.

A proposal is made to develop a contractually negotiable communication channel within industry based on a technical "Right to Know" to counter existing disabling restrictions of the security "Need-to-Know." (Authors in part)

REVIEW: The theme of this paper is that conceptual problems isolate the designer from the reliability specialist and hinder the effective use of available experience data. To the extent that this is in fact a problem, the paper is worthwhile. The suggestions for correcting the situation are less specific than one might wish, but they serve as food for thought for those who may be in a position to take the necessary action. Certainly the idea of removing every possible barrier to the interchange and effective use of data is good. However, its implementation is not likely to be easy. ##

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3/65

63A 23882

Serial Number 1880
ASQC Code 830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A practical approach to reliability in turbomachinery

AUTHOR: James C. Riple, AiResearch Manufacturing Division, The Garrett Corporation

SOURCE: 10 pp., presented at the National Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, California, September 23-27, 1963, Society of Automotive Engineers paper 744D

PURPOSE: To show how conventional engineering produced a highly reliable piece of equipment.

ABSTRACT: It is submitted that the outstanding service record of the AiResearch Turbocompressor supports the thesis that conventional engineering project organization, procedures, and techniques are suitable for the design and development of highly reliable, although complex, mechanical equipment. Each step in the design and development process must, however, be pursued to a suitable degree of excellence. The required degree of excellence may be achieved by greatly expanding and strengthening the hard core elements of the normal design and development process. Application of the procedure to similar programs should lead to similar satisfactory results. (Author in part)

REVIEW: The term 'good engineering' covers the development of any device upon which there are certain requirements and constraints (however vague or specific they may be). Traditional engineering has always been concerned with product performance, product life, product cost, etc. although, in any particular case, the degree of emphasis on each may vary widely from that in another case. It is also true that long life has not been one of the major requirements for many devices (to put it mildly) and reliability engineering has grown up in an effort to help engineers who suddenly find a new and disconcerting requirement on their efforts.

The thesis of this paper is a good one--long, trouble-free life can be achieved by merely (?) applying the necessary engineering methods. There may be an implication to some readers, however, that the use of statistical concepts are not necessary, ever, in high reliability. This would be unfortunate since part and product variability can sometimes be very great and very disturbing. Apparently in this case, variability was no great problem since it is not mentioned.

The paper, in general, is a good one and worth reading by those who are responsible for reliable products. ##

33-1

63A23884

Serial Number 1881 -1
ASQC Codes 830;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Hydraulic fluid contamination study

AUTHOR: N. F. Robinson, Aircraft Division, Douglas Aircraft Company, Inc.

SOURCE: 6 pp., presented at the National Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, California, September 23-27, 1963, Society of Automotive Engineers paper 749D (abstracted in SAE Journal, vol. 72, January, 1964, pp. 76-77)

PURPOSE: To report on a study made on hydraulic fluid contamination in naval aircraft.

ABSTRACT: A survey was made in which 144 hydraulic systems were sampled and checked for particulate contamination. The resulting data showed the condition of the hydraulic fluid and permitted evaluation of various types of filters, maintenance practices, and system design features. The fluid sampling system is described; it was designed to provide samples without additional contamination and with as little disturbance of the hydraulic system as possible.

The results broken down by filter type showed that the systems using paper filters are, on the average, cleaner than the systems using wiremesh filters. Sintered bronze filters (though used in only one type of aircraft in the survey) appear to perform nearly as well as the paper filters. When analyzing the test data further, it was found that total flight time or time since overhaul is no indication of the fluid contamination level. System pressure and type of hydraulic pump were also unrelated to the contamination level. Low oil viscosity was sometimes associated with contamination, but the relationship was not well defined. The conclusion reached from these findings is that contamination levels worse than Class 5 should not be permitted, and Class 4 levels or better are highly desirable.

It is sometimes said that if there were only careful maintenance, contamination problems would largely disappear. This survey contradicts that idea. In fact, in some patrol bomber squadrons where there is relatively little emphasis on hydraulic cleanliness, the systems were quite clean; in other fighter squadrons where hydraulic cleanliness was practically an obsession, the systems were very dirty. It seems that little will be gained by an intensive campaign for cleanliness. Maintenance manuals written years ago reflect the opinions of that time, and there is little pressure to change them, particularly on an obsolete airplane. Unfortunately, opinions rather than facts have been the basis for many decisions in the field of filtration. Some maintenance manuals for airplanes equipped with paper filters instruct that if a filter element is dirty, it should be cleaned with a solvent and a soft brush, and reinstalled. This is worse than useless. Any-

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

thing that may be seen and brushed off the surface of the element is too coarse to clog it. The particles that clog the filter are embedded in the pores of the medium, where brushing cannot affect them. The MIL-F-5504 paper filter elements, once removed, should be discarded. To try to reuse them is false economy. Cleaning of wire mesh elements at the squadron level was judged to be equally useless, and was recommended to be discontinued.

Filter manufacturers are now offering a variety of improved media, both in high temperature, all-metal types and in impregnated fiber types. The test data so far available indicate an impressive performance. The new filters meet or exceed the requirements of specifications MIL-F-8815 or MIL-F-27656. It is recommended that they be used on newly designed systems. The use of a differential pressure indicator, which is part of a MIL-F-8815 filter, assures not only that a loaded filter element is removed, but also that an element is not removed prematurely. This is an important feature, since it is suspected that a great deal of filter capacity is wasted by premature removals.

For system design purposes, it appears that a maximum permissible flow, in gpm/sq in., should be determined for each type of filter medium, based on filtration efficiency and on permissible pressure drop. The lesser of these figures governs the flow rating of a filter element. An additional "complexity factor" may be needed to increase the size of the filter when a high particle generating capacity exists. Extra-fine filtration on ground support equipment can contribute significantly to cleaner systems. (Author in part)

REVIEW: This appears to be a realistic appraisal of the hydraulic contamination problem. Designers and maintenance supervisors should be familiar with the results of this study. Apparently, those who write instruction manuals would do well to read the paper also.

The results of the study support the position that good sound engineering will go a long way toward producing reliable systems.
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Serial Number 1882
ASQC Code 800

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Proceedings of Relay Conversazione held at R.R.E. on 28th February, 1963

AUTHOR: N. E. Hyde

SOURCE: R.R.E. Memorandum No. 1991, Royal Radar Establishment, Ministry of Aviation, Malvern, Worcestershire, England

PURPOSE: To present the four papers and ensuing discussion at the Relay Conversazione held at the Royal Radar Establishment in February 1963.

ABSTRACT: About 100 people attended this symposium held at and sponsored by the Royal Radar Establishment in England on February 28, 1963. The titles and contents of the first two papers were:

Relays and relay problems, by N. E. Hyde
- Choosing a relay
- Miniaturization
- Reliability
- Low-level switching

Can semiconductor switching replace the relay? by L.W.D. Sharpe
- Size and weight
- Reliability
- Power rating
- Sensitivity and power gain
- Operating speed
- Temperature rating
- Cost

A discussion followed these two papers and is recorded. The last two papers were:

Relay requirements for modern circuits, by R. A. Harding, which dealt with some tests on mercury wetted contact relays, dry reed contact relays, and miniature plug-in relays.

Resumé -- Contact theory and research, by John Pullen, which dealt with contact make-and-break on a microscopic level.

The discussion on these two papers was recorded plus some general discussion with regard to military specifications and reliability.

REVIEW: The papers are interesting to one who is really concerned about relays but probably not to the general reader. The discussion is somewhat broader in scope, but little information is given which would be of interest to the designer. As the name implies, the proceedings were rather informal and the airing of problems was perhaps the important thing. ##

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ASQC Codes 555;843

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability calculations

AUTHOR: George Feinman, Andrea Radio Corporation, Long Island City, New York

SOURCE: Electrical Design News, vol. 8, November, 1963, pp. 86-87

PURPOSE: To give nomographs for solving the exponential equation and the parallel redundancy equation.

ABSTRACT: The probability of success for a mission is $P_o = e^{-t/T}$; the probability of success for N items in active parallel redundancy is $P_N = 1 - (1 - P_o)^N$, where the symbols have their usual meanings. A nomograph is presented for solving each equation and examples are given of their use.

REVIEW: The nomographs appear to be properly constructed and the equations are correct. There are several unstated assumptions which may be restrictive.

1. Obviously the equation for P_o assumes "Poisson" or "exponential" behavior. This implies no infant mortality or wearout, or catastrophe-inducing environments.

2. The equation for P_N assumes that the failure probability of each system is the same as that of the others and is unaffected by the state of the other systems. ##

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Serial Number 1884 -1
ASQC Code 775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Need for improved non-destructive testing methods

AUTHOR: A. Nemet

SOURCE: The Engineer, vol. 215, pp. 359-360, February 22, 1963

PURPOSE: To show some of the directions in which non-destructive testing should be developed.

ABSTRACT: The problems of industry in applying non-destructive testing (NDT) to its needs have been investigated by a working party of the British National Committee for Non-destructive Testing. Since its report is of general interest to many industries who use non-destructive testing methods and who manufacture test equipment, it is listed in detail, independently for each of the three industries. The findings are, for example:

Power generation industry:

(a) Measurement of thickness of pipes from the outside to detect corrosion pitting. Ultrasonic methods seem most suitable. (b) Measurement of the depth of surface cracks to see how serious they are. Again ultrasonic methods seem suitable. (c) The examination of weld roots while large forgings are still hot (up to 300°C). Techniques are available for the cold checking. (d) Tightness of an expanded joint.

Aircraft industry:

(a) An integrated system of construction, maintenance and NDT. (b) Acceptance standards for NDT techniques now in use. (c) Prediction of weakening by fatigue. (d) Soundness of spot welds in light metals. (e) Adhesion bond quality. (f) Wall thickness measurement of hollow turbine blades. (g) Establishment of a central agency to handle tough problems. (h) Improvement of test equipment for routine maintenance. (i) Ways of checking for non-visible corrosion more easily.

Iron and steel industry:

(a) Detection of piping and segregation in hot steel billets. (b) Chemical composition of steel tubes. (c) Surface inspection of plate. (d) Detection of defects in fast-moving steel strip. (e) Depth of case hardening. (f) Less expensive ways of checking flaws in castings.

Two points come to mind in examining the problems listed. The first one is the similarity of requirements between industries which are in no way connected, the second is the need for considerable research and development on improvements of existing non-destructive testing methods and, particularly, on the physical connection between the instrument and the product under examination. This often includes sample handling. (Author in part)

REVIEW: This is a good statement of many of the problems involved in NDT.

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R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

Some of the X-ray problems are being solved with the new electronic means of projecting X-ray patterns. Two-dimensional displays of ultrasonic tests are being developed also. (See, for example, the paper covered by Abstract and Review Serial Number 1721.)

Much more time and effort seems to be devoted to this subject now than was the case a few years ago. The effort should show improvements in both things to look for, their correlation with life or strength, and instruments to make the looking and checking easier. ##

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ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Mechanical and metallurgical causes of failure

AUTHOR: Horace Grover, Battelle Memorial Institute, Columbus, Ohio

SOURCE: Metals Engineering Quarterly, vol. 3, February, 1963, pp. 15-23

PURPOSE: To examine the use of the term "mechanical and metallurgical causes of failure" of engineering metals.

ABSTRACT: In this paper, mechanical and metallurgical causes of failure of metals and alloys are discussed very briefly from three viewpoints.

First was a look at the historical development of increasingly complex conceptual models. In the beginning, failure was viewed primarily on the basis of the theory of elasticity of a continuous body. Next, ideas were extended to elastic-plastic continua. About the same time, the atomic nature of solids was discovered, and theories of the behavior of ideally periodic lattice structures were developed. More recently, it appears that much of the mechanical behavior of engineering materials is governed by imperfections or departures from ideal crystals, and still more complex models (for example, lattices with arrays of dislocations and point defects) are being considered. Meanwhile, the physicist is learning more about atomic binding in the solid state.

Failure was also viewed by consideration of the scale of observation and analysis. When these are at rather large dimensions (1 inch or more), different terms are used to describe "mechanical causes" and "metallurgical causes" of failure. As the scale level decreases, these differences disappear until the metallurgist, the mechanical engineer, and the physicist all speak in terms of atomic models with imperfections relative to ideal periodicity. One current problem is that of defining correspondence principles so that one can judge when and how to usefully proceed on a particular scale. For example, continuum stresses and strains can be considered as some sort of statistical average of stresses associated with dislocation arrays. But, it is difficult to determine when such averages are valid for computations to prevent failure.

Finally, some comments were made and some illustrations shown from an engineering point of view. The scale of consideration in practical situations is frequently in the inch or millimeter range. Common "defects" include: small geometrical stress concentrations, corrosion pits or thinning and inclusions. Failure originating from such defects may be of several modes contingent upon the loading and the metallurgy. The mechanical engineer faces increasingly complex enumerations of requirements in stress-time history (and temperature-environment conditions) as technology advances. The metallurgist faces increasing needs for analysis of ability

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to meet these, particularly as he devises alloys much improved toward one requirement (for example, tensile yield) with some necessary compromise in some other property (such as ductility). The total trend is toward need for ever more detailed analysis.

One conclusion from this example is that prevention of failure may require consideration of every stage: casting, forming, machining, shipping, and assembling, as well as service operation.

The examples suggest several ideas in relation to causes of failure:

1. Engineering failures stem from one or more mechanical or metallurgical defects. Some are virtually unavoidable; others can be avoided by suitable attention to every process involved in the history of the part; actual care must be tempered by economic considerations.

2. Failure may occur in different modes (three, defined in engineering terms have been illustrated--some others mentioned). At present, it is common practice to estimate the mode most critical for a particular situation and plan to forestall this. In some instances an important mode may be overlooked; in others, more than one mode must be considered in detail.

Although not specifically illustrated here, a rather recent engineering approach has been:

3. Accept the possibility of some degree of failure and plan to prevent major catastrophies. Examples might include: the "fail-safe" concept in aircraft, the use of "crack-stoppers" in some structures, or the use of a "fracture-tough" material to prevent brittle fracture.

The present picture of causes of failure is complex. There is current need to seek perspective for the different points of view of mechanics, of metallurgy, and of physics. In this perspective, it is helpful to keep in mind that basic concepts of failure are not static but are in a state of evolution. (Author)

REVIEW: This is a good paper written from an advantageous point of view which is not too often encountered. While there is no intent to show how to solve problems, reading the entire paper can give designers and other engineers a more comprehensive view of failures. This is especially true where high reliability is involved.
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4/65

65A18720

Serial Number 1886
ASQC Codes 771;782;844;
851

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability testing

AUTHOR: Harold C. Jones, Aerospace Division, Westinghouse Electric Corporation

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 83-100

PURPOSE: To outline the basic disciplines involved in reliability testing.

ABSTRACT: Reliability testing is an extensive and diverse subject, involving a variety of activities. However, a few basic disciplines provide the foundation for these activities. They include statistical test designs, effects of adverse environments, analysis of results, confidence interval estimation, accelerated testing, and test planning.

In order to evaluate the effects of adverse environments, it is essential to have a thorough understanding of mechanisms of failure. Principal effects and typical failures induced are tabulated for a variety of environments.

The following major subjects in statistical test design are outlined: (a) part testing where time and confidence are specified, (b) sequential testing, and (c) analysis of variance. The major steps in test planning are described. The need for accelerated testing and some of the problems and pitfalls which it involves are discussed.

REVIEW: This paper formed part of a tutorial session on reliability fundamentals at the symposium. It covers a wide range of topics pertinent to the general subject of reliability testing; consequently it does not delve deeply into any of them. Most of the material seems to have been drawn from the references which are cited in the paper. The newcomer to the field will find the paper useful in conveying a brief general picture of the topics. Details will have to be sought from the references and other sources, as the author has stated. ##

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65A18721

Serial Number 1887
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: NASA's application of NPC 250-1 in incentive contracts

AUTHOR: Abraham I. Moskovitz, National Aeronautics and Space Administration, Washington, D. C. 20546

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 101-106

PURPOSE: To present the interrelationship between contract incentives and their effects on the application of NPC 250-1.

ABSTRACT: The paper discusses the relationship between the NASA Reliability Publication NPC 250-1 and incentive contracts. A few statistics are presented to show the breakdown of incentive contracts as to numbers, types of procurements, and types of incentives. The number of such contracts negotiated has increased from two in 1961 to forty in 1964. NASA's emphasis on incentive contracting is based on the feeling that this procurement technique leads to improved performance, timely delivery, and reduced costs.

The three incentives of cost, schedule, and performance are discussed briefly. Negotiations for incentives are generally long and involved processes. All incentives are interdependent; trade-offs must be made. Good teamwork between NASA and the contractor is essential. NPC 250-1 is the key working document.

Eight potential problem areas in the application of NPC 250-1 are: (A) understanding of NPC 250-1, (B) reliability program plans, (C) contractor obligations, (D) trade-offs, (E) integrated test program, (F) parts program, (G) specifications, and (H) assessment contractor. Possible sources of difficulty are discussed. It is indicated that NPC 250-1 can be completely, successfully, and effectively implemented in NASA incentive contracts, given the necessary understanding and cooperation on the part of contractors.

REVIEW: This discussion of potential problem areas in the application of NPC 250-1 will be of particular interest to present and future NASA contractors involved in incentive contracts. Most of the problem areas are general and apply to all contracts with reliability requirements. The presentation of statistics on incentive contracts is informative. The discussion of types of incentives and their interrelationship is rather general.

For other papers dealing with NPC 250-1 see Abstracts and Reviews Serial Numbers 1495, 1761, and 1826. ##

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65A18722

Serial Number 1888 -1
ASQC Codes 813;814;871;
881

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Cost-effectiveness analysis for optimal reliability and maintainability

AUTHOR: E. S. Winlund, Assistant to the Director, Reliability Control, General Dynamics/Astronautics, San Diego, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 107-114

PURPOSE: To present a method for determining the optimum reliability and maintainability of a system, above or below which the system effectiveness per unit cost is degraded.

ABSTRACT: The operational reliability of most military and space systems is probably no higher than 80%, and perhaps much less. So for every five systems supposed to be operational, only four or less really work when the button is pushed. The consequences of this are loss of effectiveness and high costs associated with unreliability.

The military has faced up to the problem by insisting that reliability be treated quantitatively, and by putting "goals" into most major contracts. Finding such goals largely ignored by design engineers, the goals are being replaced with "requirements." The basic dilemma is that the procuring agency cannot say how much reliability it wants until it finds out what various reliability levels will cost. Some agencies are still insisting on 100% reliability, indicating that they are thinking of it as a quality control problem rather than a creative design problem. 100% reliability would cost more than the national budget.

A logical solution to the problem lies in relating reliability and maintainability to cost through cost-effectiveness analyses. This involves the quantitative comparison of the actual accomplishment of the system with its total long-term cost, for alternative system designs. Cost-effectiveness analysis techniques for system selection have been made mandatory for all new system RDT&E proposals over $25 million through DoD Directive 3200.9, which is excerpted in the paper.

System effectiveness of a launch vehicle can be measured by the product of ready availability, countdown reliability, and flight reliability. Program cost is the sum of acquisition cost (development, production, and installation) and user cost (operation and maintenance). Formulae are devised to relate these costs to levels of reliability and maintainability. Cost-effectiveness is the ratio of system effectiveness to program cost. Cost-effectiveness is plotted against reliability and maintainability improvement ratios to locate the most desirable values. Con-

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straints on maximum program cost and minimum system effectiveness are inserted after finding the best achievable cost effectiveness, in order to evaluate the appropriateness of the constraints themselves.

A typical launch vehicle is treated as a quantitative example, using real state-of-the-art numbers. The analysis indicates that a 10-to-1 improvement in MTBF would yield almost 3 times as many effective vehicles per $100 million. Ten pertinent references are cited. (Author in part)

REVIEW: This is a good clear discussion of cost-effectiveness analysis accompanied by a realistic example. The references cited will be of use to those who desire more details.

A point which may bother the "purist" in dealing with this analysis is the arbitrary nature of the formulae which are used in relating reliability acquisition cost to reliability improvement ratio, maintainability acquisition cost to maintainability improvement ratio, etc. The author has indicated that these formulae have been determined after much trial and testing, and that others have been tried but did not significantly alter the results. In a private communication he has commented further that although different formulae gave different answers, they all came out with the conclusion that the order of 10-to-1 reliability improvement is desirable, and that maintainability improvement would bring little if any benefit. This is a good example of a situation in which one must rely on empirical results and engineering judgment.

Some other papers dealing with the economic aspects of reliable systems have been covered by Abstracts and Reviews Serial Numbers 903, 1199, 1230, 1234, 1271, 1297, 1298, 1303, 1691, 1828, and 1834. ##

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4/65 65A18723

Serial Number 1889 -1
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A model for determination of incentive fee

AUTHORS: E. A. Polgar, Lockheed Missiles and Space Company, Sunnyvale, California and J. H. Yueh, Hughes Aircraft Company, Culver City, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 115-124

PURPOSE: To outline a procedure for final fee determination when a Cost-Plus-Incentive-Fee (CPIF) method of contracting is used, and a reliability requirement is included.

ABSTRACT: The basic premise of the plan presented in this paper is that the contractor is willing to take a risk of having essentially all of his fee eliminated when contract performance is very poor and, in return, be awarded a substantial increase in fee over the negotiated target when contract performance is superior. In government contracting the Armed Services Procurement Regulations (ASPR) currently limits the final fee to a maximum of 15%. The four incentive factors included here are: (1) cost, (2) schedule, (3) product performance, and (4) reliability. A target cost and fee are negotiated by the customer and contractor prior to contract award. The cost incentive is applied by savings from under-runs being shared by both parties on a pre-determined basis, and by over-runs reducing the target fee, with limits on both under-runs and over-runs. The incentive fee is determined by the algebraic sum of points scored based on schedule, product performance, and reliability. Cost and schedule are readily determined. Performance parameters can be either continuous or discrete variables; a rating method is cited for each case. Reliability is to be measured by truncated sequential decision procedure. In addition, numerous administrative factors must be negotiated if a CPIF contract is to be managed in an orderly manner.

REVIEW: The topic of incentive contracting and reliability is receiving increased discussion, but apparently is not being widely applied. This paper recommends a procedure for a space vehicle, but no actual experience is cited. Most features of the procedure appear to be generally applicable. The typical difficulties with measuring reliability will be pertinent in an actual application. For example, how well do reliability test conditions simulate use conditions; how valid are the underlying statistical assumptions; and how to handle the chance element (producer's risk)? Both the contractor and customer should proceed very cautiously with implementations. The customer must be willing to accept results of the contractor's attempt to maximize his fee, which, if reliability is very costly, could possibly come about by concentrating on cost

and schedule achievement. The paper will be of background interest to those developing or negotiating reliability incentive contracts. Although one can speculate about many potential problems in this area, it is worthy of discussion because it is a facet of the heretofore generally missing relationship between demonstrated reliability and profits in government contracting. ##

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65A18724

Serial Number 1890
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Status of reliability requirements in government contracts

AUTHOR: E. F. Dertinger, Product Assurance Manager, Raytheon Company, Equipment Division

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 125-135

PURPOSE: To report on the status of reliability requirements in government contracts, based on data, in order to emphasize the need for additional future work.

ABSTRACT: Considerable emphasis has recently been placed on cost reduction programs at all levels of the Federal Government. If the government proceeds to reduce costs in the customary manner of buying to a low bid concept, maintenance and support costs will be higher for the next ten years than for the past ten unless equal emphasis is placed on product quality and reliability. It has repeatedly been said during the past three or four years that every new equipment contract will contain quantitative reliability requirements. An evaluation was made of the reliability requirements contained in government bid requests responded to by five Raytheon divisions during 1963. Various tabulations are charted. Of 324 total bids submitted, 79 had some sort of reliability requirement, of which 32 had properly specified reliability requirements. Similar figures are presented from a number of other companies doing government work, with similar results. Recommendations are made based on the indicated current situation. The government should apply quantitative reliability requirements, and the cost effectiveness philosophy should be emphasized.

REVIEW: The data presented here are a welcome supplement to the type of paper which is a general plea for continued efforts by reliability and quality personnel. The figures presented make one wonder: if after ten years of reliability efforts there is so little acceptance, what really is the problem? Whatever the answer, the current attention to total costs and reliability, which is endorsed by the author, should provide healthy direction.

Figure 2 on a sample tabulation of 79 bid requests can be misleading without simultaneous consultation of the text, which explains that the marketing organizations sent only 79, of the total of 324 bids made, to the reliability departments. Thus, over-all results are in reality lower than shown in Figure 2. ##

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Serial Number 1891
ASQC Codes 770;782;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Improving mechanical reliability of digital computers

AUTHOR: Quentin G. Marble, International Business Machines Corporation, Space Guidance Center, Owego, New York

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 136-143

PURPOSE: To report on the relative success of using screening at all assembly levels involving temperature, pressure, acceleration, sinusoidal and random vibration to improve the reliability of a space guidance digital computer.

ABSTRACT: Recent studies of acceptance environmental test data and field reliability data have shown that mechanical reliability aspects of the digital computer have a significant impact on the overall reliability and become the dominant factor affecting reliability where electronic circuit design margins are adequate. The type of mechanical reliability of concern in digital computers relates to failures in the circuit conductors between active elements and does not involve rotating or sliding mechanical components. Most of these circuit conductor or connection failures have in the past been considered as random failures and were included in the component part failure rate. The recognition of conductor and connection failures and identification of basic failure mechanisms through failure analysis of materials has focused attention on the problem of early detection and corrective action. The corrective action has led to frequent changes in manufacturing processes and incorporation of environmental screening tests to verify uniformity of these processes. This paper presents data obtained under both vibration testing and field use from a sample of 34 central computer units. An evaluation of the data indicates that having tested these units under a vibration screen prior to shipment eliminated approximately one-half of the potential failures. Thermal cycling test environments have also been found to be effective as a screening test for detecting process variances with certain types of packaging. The characteristics of typical failure modes are described and their relation to screening test techniques are explained. The application of environmental acceptance testing for screening mechanical defects spans a wide spectrum from component parts to final assemblies level of the computer. The identification of potential failure mechanisms prior to shipment accelerates the rate at which corrective action is implemented. This, in turn, accelerates the rate of growth of reliability number for early production models. (Author)

REVIEW: This is a good paper on a timely subject. It should be of value to design engineers. ##

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Serial Number 1892 -1
ASQC Codes 822;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability and failure distributions of inertial sensors

AUTHORS: Lee Weaver and Ted Scarlett, Honeywell, Inc.

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 144-153

PURPOSE: To give a better understanding of the factors that affect the reliability of the floated type of inertial component.

ABSTRACT: Inertial sensor failure modes are described, and emphasis is placed on the importance to reliability of having an adequate margin between device performance capability and the limits defining degradation failure. Mathematical equations for the reliability characteristics of inertial sensors are established. They show that

1. Catastrophic failures have a Poisson distribution, conforming to the traditional approach to reliability analysis.
2. Degradation failures were not Poisson-distributed, but in the case of accelerometers the distribution showed a high infant mortality, and in one case of gyros it showed the onset of wearout (not to be confused with spin motor bearing wearout).

An understanding of these failure modes and their distributions enables one to optimize mission reliability by such techniques as factory aging or scheduled retirement from service. The mathematical models facilitate predictions of mission reliability and computation of logistic support. Modifications incorporated as a result of reliability experience show a dramatic reliability improvement. An immediate result of this study is the identification of an optimum, or low failure rate period during the lifetime of these electromechanical devices.

The mathematical models developed in this paper can be used for several reliability analyses of inertial components and systems. These applications can, in general, be categorized as follows:

1. Short mission time applications (less than one hour) where the inertial platform is non-recoverable. A typical example here would be a ballistic missile application.
2. Long mission-time applications such as some satellite or space vehicle operations.
3. Missions wherein maintenance may be permitted during or after the mission. These would generally be manned space missions or earth-bound systems such as drones, submarines, suborbital weapon systems, and many commercial applications. (Authors in part)

REVIEW: It is important to acquire as much information as possible on the failure properties of electromechanical devices. This paper

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is a contribution to the solution of that problem. (The use of the words "random" in reference to the Poisson distribution and "not-random" in reference to other probability distributions should be discouraged. All probability distributions are distributions of a random variable. Empirical curve fitting is well commented upon in the paper covered by Abstract and Review Serial Number 1739.) ##

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Serial Number 1893 -1
ASQC Codes 713;821

713;820

713;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Panel discussion--Structural reliability

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 154-181

This is a set consisting of the three papers which are considered separately below.

TITLE: A basic approach for structural reliability 65 A18727

AUTHOR: G. E. Ingram, ARINC Research Corporation, Washington, D. C.

PURPOSE: To introduce the notion of probability into structural design.

ABSTRACT: Traditionally, structural designers have used safety factors to account for unknown loads. In some cases, probability distributions are known for both stresses and strengths. When such is the case, unreliability (probability of system failure) can be calculated.

REVIEW: This material is neither new nor, by now, profound. The point is apparently worth repeating since authors keep repeating it. The essential content of this paper has appeared elsewhere in the literature, although no references are cited.

It is worthy of note that the approach given here is very easy to misuse by those who do not understand the application of mathematical models. This point is well illustrated, unfortunately, by the following two papers.

TITLE: Implementing a structural reliability program 65 A18728

AUTHOR: Edward B. Haugen, North American Aviation, Inc., Space and Information Systems Division, Downey, California

PURPOSE: To show how statistical descriptions of stress and strength are used in structural design.

ABSTRACT: The properties of materials and the stress data must have a statistical description if statistical methods are to be used. The Normal (Gaussian) distribution is convenient because a linear combination of Normal deviates is itself a Normal deviate and no other distribution has this property. If the distributions of stress and strength are known, the probability of failure (the probability that stress exceeds strength) can be calculated.

REVIEW: This paper is an example of the mistreatment and misuse of

mathematical models mentioned in the review of the first paper in this set. Review Serial Number 1185, which covered an earlier paper by the same author, is applicable to much of the present paper. Some additional comments pertinent to this paper are given below.

1. Even though randomness can be associated with physical quantities, there are many engineering situations where the effect of this randomness is negligible and the situation is properly treated as if there were no uncertainty.

2. "Actually, based on observation, one of three distribution classes will approximate most of the parameter distributions found in structural design practice." This is a most misleading statement when taken in the context of the paper. It is the more misleading because it is often true and the play is on the word "approximate." If the predictions of frequency are to be accurate within $\pm$ 10%, many distributions are quite adequate for describing any particular physical situation. If, now, $\pm$ 1% accuracy is desired, much trouble may be encountered in finding a tractable and well known distribution to fit the physical situation. If $\pm$ 0.1% accuracy is necessary, it is unlikely both that the physical world is known that well and that, even if it were, a tractable, well known distribution would fit it. If accuracies of $\pm$ 0.01% = $\pm 10^{-4}$ or below are required, it is sheer folly to think that any mathematical model will come at all close to predicting the required probabilities.

3. Only unimodal distributions are considered in the paper. But it is not unreasonable to suppose that small peaks may exist away out on the tails of the actual distribution. There is virtually no way of finding them even if they do.

4. The area under the intersection of the stress and strength distributions is not the probability of failure, nor, in fact, is it anything but the area under the intersection. The probability of failure is given by the probability that strength minus stress is less than zero. The calculation is more complex than that for the area under the intersection of the distributions.

5. The Z introduced by the author is not a random variate since it is calculated (according to the author's formula) from quantities known precisely.

6. The central limit theorem can be very useful, but again the comments under 2 apply. All the theorem says is that the distribution tends toward Normality as the number of summed distributions becomes large (and no one distribution makes up virtually all the sum by itself). It says nothing about how many it takes to come how close on the tails of the distribution--and that is where we want to use the distribution, well out beyond the 10^{-3} part of the tail.

7. The author shows undue concern about the fact that the Normal distribution predicts negative values of strength. Of

course it does, but it has long since ceased to be an adequate model by that time. Thus if we say that the Normal distribution is an adequate description within $\pm$ 3σ of the mean, what it would predict outside that range is of no concern to us. We may want to know what goes on out beyond there, but wanting to and actually knowing are two different things. Strangely enough, no worry is given to the fact that the log-Normal predicts "infinite" values of the strength (more of them even than does the Normal).

8. "Values beyond 6 or 7 sigma from the mean are of little more than academic concern." This is very true, but it is not stated strongly enough. Values beyond approximately 4σ are of absolutely no engineering concern with regard to relative frequency.

9. "From characteristics that the classes of structural alloys discussed display (e.g., scatter that tends to be narrow), it may be suspected that some of these distributions closely approximate the Normal distribution form." The example obviously has nothing to do with the distribution's being Normal, nor is it otherwise clear why it should be.

10. "The equations show that as $\sigma/\bar{\bar{x}}$ approaches zero, the log-Normal approaches the Normal distribution." As mentioned in 2 and 6, the problem is not so much 'does the log-Normal become Normal?', but 'how close does it come and by what criteria is closeness judged?'

11. The formula for combining standard deviations assumes no correlation between the variables, which may be a severe restriction. For example, there may well be strong correlations with time.

12. "The probability levels guaranteed by these lower bounds are of little aid, since we must normally design for $P_F < 10^{-6}$." Rarely if ever can a designer accurately calculate probabilities of failure less than 10^{-6} as explained in 2. He may use large safety margins, but he cannot calculate the probabilities associated therewith because his models are in no way that accurate.

13. "The situation may exist where the allowable-stress variate is described with probability 0.999 (P_F = 0.001) and the applied-stress variate with probability 0.999 (P_F = 0.001). The probability of simultaneous occurrence of both applied and allowable stresses in regions of 'unreliability' is given by $P_F = (0.001)\cdot(0.001) = 10^{-6}$." From the statement of the problem it is not the intersection (logical product) of the two events but the union (logical sum) that is desired. Assuming that the stress and strength are statistically independent, then $P_F = 10^{-3} + 10^{-3} - (10^{-3} \times 10^{-3}) \approx 2 \times 10^{-3}$.

14. "It is not unusual that, with the size of sample avail-

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able, any one of several statistical models fits the available data equally well near the area of central tendency, where most of the data plots. For the tails of the distribution, there is not enough data for adequate definition. The rare occurrences of very low strength and/or very high load intensity fall precisely into these regions of the distributions where definition is least good." This is an excellent statement. If it formed the basis for the paper, the result would have been much better.

15. The computations associated with Figure 10 and equivalence of the Normal and log-Normal are not at all clear as to purpose or result.

16. For a system of any kind, $1/Z(s) = L(\text{output})/L(\text{input})$ is called the transfer function (for a discussion of nonlinear transfer functions see Reference 20)." This is true only for linear systems (perhaps the author's parenthetical remark was intended to imply this).

17. Not all systems are amenable to treatment by the simple stress-strength model. For example cumulative damage may occur due to the application of a damager (sometimes also called stress) and then a different type of model is much more convenient and useful.

As a rule of thumb with regard to extrapolation on a model, use this statement: Extrapolate a probability density function no further than you would be willing to accept a datum on a test without calling it an outlier (extraneous). This will generally limit most situations to $\pm 3\hat{\sigma}$ ($\hat{\sigma}$ is the estimated standard deviation). It tends to be "self-enforcing" if adopted since engineers many times are all too prone to throw out data which are "obviously off."

65A18729

TITLE: Structural reliability--the general engineering design approach

AUTHORS: C. Dicks and S. Wilson, Apollo Support Department, General Electric Company

PURPOSE: To show how structural reliability can and should be calculated.

ABSTRACT: The reliability of a system is directly proportional to the reliability of its mechanical structure. Each part may fail or not depending on the loads applied to it and on the criteria for failure. The allowed stress (usually called strength) and the actual stress are computed by a Monte Carlo process. If stress $\leq$ strength, there is no failure; otherwise the item is considered to have failed. This is repeated for 10^4 Monte Carlo trials and the reliability is estimated as the success ratio. If there are

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no failures, the lowest 10^3 points of strength minus stress are extrapolated to zero and the probability of failure read from the graph. Some examples of the mechanics of carrying out the procedure are given.

REVIEW: The basic procedure which is outlined seems straightforward enough. It may be difficult at times to keep track of all the correlations in complicated structures--especially when the correlation is not complete.

The authors' claims for advancing the state-of-the-art seem rather optimistic. Certainly the use of Monte Carlo trials with empirical and/or theoretical probability distributions is not new. The most surprising part is a reliability calculation which shows $1\text{-}R = 0.15 \times 10^{-492}$ for one condition and $1\text{-}R = 0.76 \times 10^{-19}$ for another. These calculations are entirely out of place in a serious technical article. By no stretch of the imagination whatsoever does any model describe reality that accurately. This type of exercise would lead one to think that any successes which this method may have had are due more to luck than to sense.

The main difficulty with the entire presentation is that it overlooks the fact that the data to substantiate any probability distribution for any "strength" quality, whether the distribution is grossly empirical or a common tractable one, are just not available to make reliability calculations in the region in which they are most desired. The statement that this method is successful reminds one of the story of the man who waved the broom from the roof of his house to keep away the plaid elephants. When queried about its usefulness and efficacy, he replied that it obviously worked because there were no plaid elephants around.
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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Prime contractor's view of small business suppliers

AUTHOR: J. B. McChesney, Lockheed Aircraft Corporation, Burbank, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 182-185

PURPOSE: To discuss small business regulations which prime contractors must implement, and some problems areas, including quality control.

ABSTRACT: A prime contractor's view of small business is based on: (1) his experience indicating that most small business firms are competitive, responsible and able, and (2) contractual and legal requirements. The Armed Services Procurement Regulation has procedures which prime contractors must follow in maximizing subcontracting to small business. Some problem areas are cited, including the inability of the Small Business Administration to evaluate the quality system of suppliers which they recommend to prime contractors, and the minor difficulty in categorizing a business as small or large.

Small business suppliers complain of the increased demands for quality efforts, while at the same time they are experiencing an increased squeeze for lower prices. They also complain of the parade of survey teams sent to evaluate every aspect of their business, where different teams often have contradictory requirements. These are valid criticisms. An attempt is made to obtain better balance between the practicalities of costs and the ritualism demanded by impressive survey questionnaires. (Author in part)

REVIEW: This paper briefly describes the highlights of prime contractor-small business supplier relationships, with some consideration of non-technical quality features. All-in-all, the author seems to accept the government contractual requirements, to look with favor upon using small business, to recognize the need for product quality, and to sympathize with the small business supplier in being critical of the costs required in meeting quality control "ritualism." There is an apparent contradiction in the area of compromises to small business. Compare these statements: on the first page, "The prime must supply a single standard of quality, reliability, and performance...," and on the third page, "We attempt to tailor our demands for strict conformance to our quality assurance standards to the size of the supplier...." However, in a private communication the author has explained that acceptable variation may exist in quality management aspects of the small shop and large supplier, e.g., written standards and procedures, and a feed-back system. ##

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4/65 65A18730 Serial Number 1895
ASQC Code 816

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Government position on quality control with small business contractors

AUTHOR: Ernest W. Brackett, National Aeronautics and Space Administration, Washington, D. C.

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 187-190

PURPOSE: To present the position of DoD and NASA on small business contractors, with emphasis on reliability and quality.

ABSTRACT: Both DoD and NASA have a mandate from the Congress, by statutes, to see that they place contracts with small business concerns to the maximum extent practicable. This is being carried out. Subcontracts are considered included in this policy, and it is believed that subcontracting is the area in which small business concerns have the best opportunities of sharing in government contract programs. Small companies which have had no experience with government contracts or subcontracts need the advice and assistance of government and prime contractors on the subjects of how to compete for contracts, of what contract terms mean, and of what will be expected of them in their performance. This applies particularly to the reliability standards and quality control programs which are expected. Close communications between small business contractors and the sources of their contracts are important. There are good opportunities for small companies in government prime and subcontracting, and there are commercial fallout benefits for those who learn what high reliability can produce. (Author in part)

REVIEW: The current situation of the small business contractor in government procurement is summarized in this paper, and no new or controversial points are made. Brief mention is made of reliability and quality. The recommendations which are made on communications in the paper and which are cited in the above ABSTRACT are appropriate. Two names were mentioned in this paper without further reference; both persons mentioned presented papers on small business at the same symposium. Abstract and Review Serial Number 1894 covers one of these papers, and the other paper is not in the proceedings. ##

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Serial Number 1896
ASQC Codes 815;816

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Panel on small business and reliability specifications

AUTHOR: Lewis G. Odom, Jr., Staff Director and General Counsel, U. S. Senate Select Committee on Small Business, Washington, D. C.

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 191-201

PURPOSE: To present some views on the present status of reliability and its significance for the future, with particular reference to small business.

ABSTRACT: Reliability in subcontracting is becoming an increasingly important area for small business. There is a need for improved communications between prime contractors and suppliers if reliability specifications are to be realistically understood. A subcontractor program must be developed to provide maximum opportunities for such communication. The paper describes the desirable features and effects of model programs which have been worked out by alert prime contractors.

Small business needs to acquire reliability capability, both to play a part in prime and subcontracting on advanced systems and to upgrade the country's industrial system. The paper points out that small business legislation intends only that small businesses participate fairly rather than on a favored basis, and that such participation has resulted in proven monetary benefits to the taxpayer.

Topics discussed in the paper include interdependence of large and small business, historical significance of reliability, trend toward commercial reliability, importance of small business values, implementing these values, a model of supplier communications, pressures of cost control, the small business subcontracting program, benefits of supplier programs, the challenge of advanced systems, the challenge of conversion, the challenge of world trade, the need for teamwork, and an opportunity for leadership by the reliability profession in bringing home the benefits of improved reliability.

REVIEW: This paper should come to the attention of management in both prime and subcontracting organizations. The author has put together a lot of ideas, apparently from a very wide range of sources, judging by the listing of sixty-odd references--some technical, some nontechnical. Broadly speaking, the paper is both a statement of a sound philosophy and an exhortation to meet the challenges of "a modern industrial revolution." ##

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Serial Number 1897
ASQC Codes 775;813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Nondestructive testing's role in reliability programs

AUTHOR: Douglas W. Ballard, Sandia Corporation, Albuquerque, New Mexico

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 202-208

PURPOSE: To present the vital role of nondestructive testing in support of a critical reliability program.

ABSTRACT: More stringent quality requirements of weapons and space programs and the need to reduce testing costs require increased employment of nondestructive testing. The reluctance of reliability engineers to accept nondestructive test results and the need for a closer working relationship between reliability and test engineers is noted. The following four major benefits resulting from proper integration of nondestructive testing techniques during development are discussed: (1) provides a source of unique reliability data, (2) provides more meaningful data from destructive and environmental tests, (3) reduces the number of destructive tests and resultant costs, and (4) provides a statistical basis for correlation of development and production test data. Some examples of successful applications of nondestructive testing methods are described. The author urges reliability engineers to become more familiar with nondestructive testing techniques and to realize the benefits of a properly coordinated destructive-nondestructive test program. (Author)

REVIEW: This paper serves a useful purpose in bringing nondestructive testing (NDT) forcefully to the attention of those who are not sufficiently familiar with it. Where 100% inspection is necessary, the test must be nondestructive. Few references to the general NDT literature are given in the paper, but the SNT (Society for Nondestructive Testing) publishes a monthly journal called "Materials Evaluation," which is a good source of information. Both the Reliability Symposium Management Committee and the SNT are to be congratulated for getting together in the sponsorship of this symposium. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: X-ray television inspection of electronic systems

AUTHOR: Robert C. McMaster, Professor of Welding Engineering, The Ohio State University, Columbus, Ohio 43210

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 209-222

PURPOSE: To describe an X-ray inspection system which has remote viewing.

ABSTRACT: An X-ray television image enlargement system has been developed to provide 30X magnification of X-ray images of electronic components, assemblies, and system components, to permit exacting inspection with 10-micron resolution. Extreme detail and high contrast resolution permit examination of miniaturized electronic components for internal assembly, positions of elements, freedom from contaminations, and quality of soldered or welded interconnections. Printed circuit assemblies can be examined in detail, and in motion, for printed conductor continuity, soldered joint quality, conditions of diodes, transistors, capacitors, coils, resistors, terminals, and leads. Such defects as partially-broken leads, cold-soldered joints, solder balls within assemblies, misplaced internal components, and contaminated semiconductors have been repeatedly revealed in inspection with this system.

The basic X-ray image system involves projection of X-ray images upon the target of an X-ray sensitive vidicon camera tube, with approximately 1400 scanning lines per inch of picture height. The enlarged images are provided on television monitors at remote locations. Complete safety of observers is possible with remote handling of test objects under the X-ray beam.

The X-ray television image enlargement system was developed in the Department of Welding Engineering of the Ohio State University, under sponsorship of Watertown Arsenal Laboratories. Commercially-available equipment is manufactured under license by Philips Electronics Instruments of Mount Vernon, New York. (Author in part)

REVIEW: This system was mentioned briefly by the author in a popular article covered by Abstract and Review Serial Number 1721. The present article offers an intensive description of the system. If the costs involved are reasonable, there could certainly be a large application of this type of unit in many high-reliability projects. (The author, in a private communication, has indicated that Philips costs are about $15,000 for the X-ray television image system and about $7500 for the X-ray source.) Several references are given for further reading. ##

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Serial Number 1899
ASQC Codes 844;850

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Demonstrating reliability for long space missions

AUTHOR: R. B. Carpenter, Jr., North American Aviation, Space and Information Systems Division, Downey, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 223-232

PURPOSE: To present a method for assessing high reliability.

ABSTRACT: Much information is presented in this paper in very little depth. The subject is as broad in scope as the programs we deal with. Establishing the requirements for an integrated test program, and applying them to the governing specifications are best accomplished by a single engineering group. Since the tools required to design the tests are those associated with the reliability discipline, this seems the reasonable place for responsibility of test design and control.

The proposed method technically accentuates certain characteristics: the pretest analysis and the test emphasis index, which provide for intelligent application of the over-stress test and the mission life test. These characteristics fulfill the need of providing a method of rigorously designing a test program so that each test can be justified on the basis of its individual contribution to the program. (Author in part)

REVIEW: The exact nature of the plan is hard to determine, perhaps because of editorial problems in the article. The need for planned integrated tests is well emphasized, but the index and synthesized reliability calculations are not explained well enough to enable understanding of them from scratch.

The author at times seems to equate statistical rigor with the class of statistical tests which assumes no prior knowledge. There can be just as much statistical rigor in tests that do use prior knowledge. The trick in either case is to have an adequate picture of the situation. The author also makes the not uncommon mistake of representing the probability of failure by the area of overlap of the stress and strength curves; there is, of course, no such relationship. The correct derivation is somewhat more subtle.

In a private communication the author has stated that the test plans referenced in the paper (AGREE-3) do not provide for the application of prior knowledge, but that such knowledge should be used. He has further indicated that the pre-test analysis is for the express purpose of providing the necessary "adequate picture of the situation." ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Environmental testing in high reliability programs

AUTHORS: J. Robert Holmes and Edgar F. Jahr, International Business Machines Corporation, Space Guidance Center, Owego, New York

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 233-239

PURPOSE: To give a descriptive account of the advantages of environmental testing.

ABSTRACT: With the trend toward shorter development times and smaller production quantities, environmental testing is rapidly becoming the major instrument for detecting weaknesses in design and production on a timely basis. Trends in testing are discussed with emphasis being placed on four types of tests, namely: step-stress, environmental screening, periodic qualification, and environmental acceptance testing.

The purposes of the step-stress testing technique are generally fourfold: (1) detection of process changes or process improvement, (2) determination of maximum ratings, (3) determination of maximum application stress, and (4) establishment of screening levels.

Environmental screening tests are nondestructive, generally of short duration, and are conducted throughout the various stages associated with the assembly process. Usually testing of this type is done on the entire population of critical parts and assemblies to weed out anomalous failures. Comprehensive failure analysis is required to supplement analysis of step-stress testing failures in evaluating failure mechanisms and establishing the most effective screening levels and methods. An important consideration also is that testing be completed well in advance of the time at which the useful life of the product might be expended.

As contrasted with step-stress testing, qualification testing may accomplish its objective with or without the occurrence of failures. The product's performance is evaluated under environmental conditions similar to, but in excess of, the conditions most likely to be encountered in end use. Periodic qualification testing under conditions of vibration, temperature, altitude, and constant acceleration allows one to evaluate the effects of changes in design, fabrication techniques, etc., judged to be potentially susceptible to certain types of environmental exposure. "One-shot" qualification does not provide for re-evaluation and consequently major potential problems can remain undetected.

The purpose of environmental acceptance testing is to demonstrate

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

the capability of each deliverable system to satisfactorily perform its function under the environments to be encountered. As such, this test is nondestructive and the system should be capable of proper performance in future use.

Because of cost and time constraints, there are definite limitations on the amount and type of environmental testing that can be done. The several types of environmental tests that have been discussed are considered basic; however, the degree to which they are implemented is dictated by the scope of the program.

Specific examples of the application of these techniques are described and their impact is discussed. Areas requiring further exploration are indicated. (Authors in part)

REVIEW: This paper does a good job of presenting the case for environmental testing. It is not too technical and is easy to follow. The points made in the paper are worthy of serious consideration by engineering groups. ##

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Serial Number 1901
ASQC Code 822

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Statistical models in mechanical reliability

AUTHOR: John H. K. Kao, New York University, New York 53, New York

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 240-247

PURPOSE: To offer background for choosing probability or statistical models in representing and analyzing failure data.

ABSTRACT: It is important in choosing a distribution function (df) that its underlying basis and assumptions be appreciated. The average failure rate and the hazard rate are first introduced. The exponential has a constant hazard rate while the Weibull has a power function hazard rate. If parts have a Weibull df, then a series assembly (chain model--weak link) of these also has a Weibull df. The Weibull has other interesting properties as an asymptotic df and as an extreme value df. Other extreme value df's are shown. For a parallel assembly (rope model) some special-case and asymptotic df's are given. These df's are compared and a derivation is given of the log-Normal df.

One important point is emphasized. In actual practice, the experimenter should not try various probability papers and choose the model which best fits his data at hand, unless the superior fit of a certain model is consistently demonstrated by data. In other words, to choose, a model by fit alone is not sufficient. It is with precisely this point that the present paper is concerned. To choose a distribution as a failure model, one must be willing to accept, or be able to justify, the set of assumptions which generates the model. If one chooses the model in this way, good fit would make him happy; bad fit should not disturb him either, since bad fit is "good" information signifying to the experimenter something wrong in the data source. Perhaps some assignable causes for heterogeniety such as a new batch of materials, a new procedure of recording data, a change in failure mechanism, etc., or any combination of these are responsible. "Lack-of-fit" in probability plots is equivalent to "Out-of-control" in control charts. It calls for actions to bring about statistical control in the data generator, before any analysis is done or interpretations drawn. (Author in part)

REVIEW: This is a good mathematical paper. The author's cautions, quoted in the ABSTRACT, are essential to an understanding by engineers of the use of mathematical models. Engineers who use these models should <u>study</u> this paper. (The failure rate as defined in the paper is actually an average failure rate over a given time period. A more usual meaning for failure rate is the instantaneous failure rate given by $dF/dt = f(t)$--in terms of the author's notation.) ##

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4/65 65A18736 Serial Number 1902
ASQC Codes 414;810

R E L I A B I L I T Y A B S T R A C T S A N D T E C H N I C A L R E V I E W S

TITLE: Game theory applied to reliability problems

AUTHOR: Victor Selman, System Sciences Corporation (formerly ITT Intelcom, Inc.) 5817 Columbia Pike, Falls Church, Virginia

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 248-253

PURPOSE: To present game theory and to demonstrate its use as an important tool in making logical decisions in reliability engineering problems.

ABSTRACT: A brief introduction to the theory of games is given. The essence of a game theory problem involves individuals or sides with different goals, whose destinies are intertwined. For example, the systems manufacturer may be conceived as being in conflict with the component manufacturer whose parts he uses in his assembly.

Several properties of a game are defined, namely: players, play, move, payoff, strategy, and payoff matrix. The fundamental "minimax theorem" is stated along with two other important theorems.

Three examples are treated in moderate detail. One example concerns penalty and incentive contracts where the manufacturer is playing a game against nature, assuming that nature acts as a malevolent. The second considers reliability procurement policies in which the black box manufacturer is conceived as being in conflict with a parts supplier. The last example treats the reliability-maintainability comparison of alternate designs.

In conclusion the author states that the theory of games becomes an important tool in reliability engineering because:

1. Game theory furnishes a rational basis for analyzing conflict of interest situations.
2. Game theory formulation of a problem often enables the designer to identify irrelevant and redundant information about competitive situations. (Author in part)

REVIEW: This is a mathematical paper and the reader would be required to read or be familiar with one or more of the referenced papers or books in order to obtain a thorough understanding of the principles. However, the applications are practical and do demonstrate the importance of game theory. There are a few minor errors in notation in Example 1; the letters a and b are interchanged with b and p, respectively, in part of the description. ##

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Serial Number 1903
ASQC Codes 413;440;822

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Transformation of the failure rate

AUTHOR: Leo A. Aroian, TRW Space Technology Laboratories, Inc., One Space Park, Redondo Beach, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 254-264

PURPOSE: To present the transformations for reducing any continuous distribution to the exponential density function.

ABSTRACT: The fundamental equations for the transformation of the instantaneous failure rate of any continuous density function are derived. For a continuous density function $f(t)$ with instantaneous failure rate $\lambda(t)$ and reliability $R(t)$, $T = \Phi(t)$ is taken to be a transformation which maps $\lambda(t)$ into $\lambda^*(T)$ such that $R(t) = R^*[T(t)]$. The two fundamental relations obtained are

$$\lambda(t)/\lambda^*[T(t)] = dT/dt \qquad (1)$$

and

$$T = -\int_0^t \frac{1}{\lambda^*(T)} \frac{d}{dt} \log R(t)\, dt. \qquad (2)$$

These results may be used to map distributions, to map failure rates, to transform any distribution to an exponential distribution, or to transform a varying failure rate to a constant failure rate. The transformation of the Weibull distribution to the exponential distribution is given as an illustration. The results are applied in finding a fixed-time test for the Weibull distribution with fixed and known shape parameter. Operating characteristic and average time-to-termination curves are given for various values of the shape parameter. (Author in part)

REVIEW: This is a mathematical paper in which the development can be followed readily by anyone with a knowledge of elementary statistics. The essential point is that by making a transformation on the random variable (see (2) in ABSTRACT), one may use the exponential distribution as the basis for subsequent analysis. The author, in a private communication, has indicated that he found the transformation of the failure rate essential in considering the fixed-time test for the Weibull distribution. The general properties of the transformation require further research. The author has also mentioned that a correction sheet distributed when the paper was given contains the exact average time-to-termination of the Weibull fixed-time test. ##

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4/65 65 A18738

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ASQC Codes 831;837;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Design techniques for reliability prediction

AUTHOR: Irving Bosinoff, Sylvania Electronic Systems, 189 "B" Street, Needham, Massachusetts

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 265-272

PURPOSE: To describe a set of techniques for use in reliability predictions and briefly indicate the fruitfulness of these techniques by an example.

ABSTRACT: This paper describes a general procedure for performing a reliability analysis. The techniques are most suited to the analysis of performance variation such as that resulting from degradation-type failures. The problems are approached by developing mathematical models which simulate the physical system (circuit) being evaluated. These models can take the form of transfer functions which relate to circuit performance requirements. If a circuit is made up of large numbers of components having characteristics described by statistical measures such as distribution functions, having characteristics which change in time in a probabilistic fashion, then circuit performance is also determined in a probabilistic way.

The functions relating circuit performance to component characteristics can be found analytically or synthetically. When the circuit is relatively simple and when the underlying density functions of the characteristics are Normal, then the distribution functions of the circuit performance parameters can be solved analytically. However, as soon as the circuit becomes complex or if the underlying density functions are no longer Normal, a Monte Carolo method is required for estimating the distribution functions of the circuit performance parameters.

The author notes the importance of checking the analysis by breadboard experiments and that the concept of failure must be clearly defined. If the distribution functions describing the system performance measures do not satisfy the performance criteria, the components must be replaced or the basic design must be modified so that circuit performance is less dependent on component tolerance. The techniques are demonstrated by using a low speed flip-flop. Two equations are developed relating its performance to the component characteristics. (Author in part)

REVIEW: This paper describes several well-known reliability techniques based on performance variation analysis. These techniques will be useful for design engineers and this paper should be read by anyone interested in such methods.

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It should be noted that the partial derivatives are evaluated at the nominal values of the component characteristics. Also the determination of the worst case assumes that the performance can be adequately approximated by a linear function throughout the region of variation of the component characteristics. One further minor point is that the measure of relative degree of sensitivity of performance to the component characteristic variation is adequate when the variation in the characteristic is some fixed percentage of its nominal value. Otherwise, the sensitivity measure might be replaced by the product of the partial derivative multiplied by the standard deviation or a fixed multiple thereof.
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Serial Number 1905
ASQC Codes 782;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: New circuitry withstands deep-sea pressures

AUTHOR: Al Rosenblatt

SOURCE: Electronic Design, vol. 13, February 1, 1965, pp. 6-11

PURPOSE: To discuss electronics which can be exposed to the deep-sea pressures.

ABSTRACT: In order for electronic circuitry to survive at deep-sea pressures, it is usual to encase it in a protective vessel. These vessels may weigh over a half ton for less than 100 lb. of gear. Thus if the vessel is eliminated, handling is vastly improved. A new approach is to encapsulate the parts in a liquid which transmits the pressure directly to all parts. The case performs the function of keeping the sea water and the liquid separated. Many components cannot withstand these pressures, especially those with gas inside the container.

Wirewound and carbon-film resistors do very well; carbon composition resistors decrease in value by 5 to 20%. Mica and ceramic capacitors are best. Inductors and transformers with magnetic cores are pressure-sensitive. Transistors can be made to work if the case is filled with a good silicone oil; in general silicon surfaces must be passivated.

REVIEW: This is a good approach to having equipment survive in a heretofore bad environment. Deep sea research and development can be expected to increase; so designers should become aware of these new problems. The article is a news release rather than high in technical content; nevertheless it is of value to designers.
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4/65

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability programs and the problem of attaining high probabilities of mission success in space exploration

AUTHOR: Nicholas E. Golovin, Office of Science and Technology, Executive Office Building, Washington, D. C.

SOURCE: IEEE Transactions on Reliability, vol. R-13, June, 1964 (published December, 1964), pp. 1-4

PURPOSE: To bring out into the open some of the reliability problems of the space effort.

ABSTRACT: The major obstacles to attaining high probabilities of mission success in future space exploration are (1) dependence on large numbers of propulsive stages in a given vehicle, (2) need to develop many more long-lived components and subsystems than has been possible to date, (3) need to improve the development process so that much less ground and flight testing is needed to provide confidence in system reliability, and (4) fragmentation of responsibilities for flight tests and for technical direction of major programs. Moreover, the current lip-service approach to "reliability" may be doing more harm than good. What is needed is (1) broader and more uninhibited discussion of difficulties of attainment of high probabilities of mission success; (2) more widespread, systematic, and intense search for possible failure modes at the system, subsystem, component, and part levels; (3) general persuasion that when reductions in funds occur, that they must largely go into stretching out schedules and not into reducing the volume of ground and flight testing; (4) integrity of communication throughout the multiplicity of participating groups; and (5) the conviction that effective and practical reliability engineering is a vital aspect of systems engineering. (Author in part)

REVIEW: This is a paper which administrators and engineers alike should take to heart. No solutions are proposed for the problems, but to have the problems frankly stated is refreshing. One important avenue to be explored is how to write contracts so that manufacturers have the normal incentives to solve these problems. ##

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Serial Number 1907
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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: How much reliability

AUTHOR: F. E. Wenger, Assistant for Reliability, Systems Effectiveness Division, Directorate of Engineering, Air Force Systems Command, Andrews Air Force Base, Washington, D. C.

SOURCE: IEEE Transactions on Reliability, vol. R-13, June, 1964 (published December, 1964), pp. 5-7

PURPOSE: To discuss the need for a real and full job of engineering on every piece of equipment.

ABSTRACT: Individually, we may be concerned about a small portion of the reliability program, such as probability of success, or economic considerations, or systems effectiveness, when we really should be looking at the whole picture. Reliability is not something that you buy by the piece or pound and just attach to the equipment. It is something that is designed and built into it. This places a great responsibility on the design engineer. He must do a real job of engineering on the equipment.

There is no pat answer to "how much reliability;" it involves many trade-offs, and the final decision will be made as a result of these trade-offs. When figuring "how much reliability," we must consider the routine engineering practices, then add how much it would cost using good reliability practices. After this is determined, one must assign a useful life span to the equipment, determine the cost of maintenance, the cost of owning the equipment, and the cost of idle equipment. From this information, good decisions can be made.

While there is no quick answer to "how much reliability," it can be evaluated and the determination made. The answer will usually be "more than it's got now." (Author in part)

REVIEW: This is a general discussion which shows that the extra amount invested in high reliability can often return far more in savings in maintenance. One rather controversial point raised is "... the design engineer must...insure that engineering practice is more than adequate to fulfill the required performance, including reliability, which is stated in the contract." Strictly speaking, it is the function of good engineering to provide exactly what the specifications call for--no more, no less. It is a function of good engineering management and contracting activity to have the specifications describe what is <u>really</u> wanted including reliability, maintainability, level of technical help required for maintenance, etc. In many cases the contracting effort has been at fault since it may have provided an inadequate description of the needs. ##

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4/65 65A11913 Serial Number 1908 -1
ASQC Codes 782;864

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Environment-resistant connector field reliability report

AUTHOR: J. E. Atkinson, General Manager, Amphenol Microelectronics Facility, Amphenol-Borg Electronics Corporation, Chicago, Illinois

SOURCE: IEEE Transactions on Reliability, vol. R-13, June, 1964 (published December, 1964), pp. 8-15 (This paper is a summation of Amphenol-Borg Electronics Corporation Report No. RC3-008, May 15, 1963.)

PURPOSE: To report on a study of the performance of connectors in jet aircraft.

ABSTRACT: Over the eleven months stretching from January, 1962 through November, 1962, the Boeing Airplane Company received reports from major domestic and international carriers having to do with connector problems occurring in the 707 and the 720 Jet Aircraft. Amphenol's engineers, working with the Boeing reliability people, have correlated report summaries to the extent that they have separated connector categories according to the specific environmental experiences which the connectors have undergone. This has resulted in the establishment of eight different environmental applications, and the data are arranged so as to produce failure rates associated with each. Also, it is possible to compare various types of connectors as to their ability to withstand extreme environmental shocks reliably.

The study involves some 173 707 and 720 Aircraft, which are approximately half the entire jet fleet. It involves 437,000 flight hours, 193,000 departures, and approximately 212,000 total connectors.

Three major failure modes evolved in this study namely:
(1) Termination failure modes, including: defective contacts; bare, loose, or broken wires; cold solder joints.
(2) Failure modes involving improperly seated connectors and including specific failures such as: loose connectors, disconnected connectors, mismated connectors (pushed back pins).
(3) Failure modes involving contamination, such as: shorts caused by dirt or moisture, high contact resistance due to dirt in a contact pair.

It is also interesting to note the many instances where the incidence of failure is dictated by the circumstances under which the connectors operated. For example, termination failures in the landing gear where cable shock is an extremely severe environment is 57 per cent of the failure from all causes. Contamination failures in the rear firewall of the engine, where high velocity exhaust gases as well as dirt and soot are prime contributors to this mode of failure, is 68 per cent of the failures from all

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

causes.

Some basic conclusions on connector field reliability under circumstances associated with commercial jet aircraft are:

(1) Connectors are, in general, able to compare with other components from the standpoint of failure rate. Typical failure rates quoted for high-reliability components are 0.02/million hr to 0.6/million hr, while those for connectors were 0.62/million hr overall to 0.05/million hr for MIL-C-26500-type connectors.

(2) Failure modes for connectors are dictated by the environments they see. As an example, consider the incidence of failures due to contamination throughout the entire aircraft. The failure rate is in proportion to the effectiveness of the connector seal. Those connectors conforming performance-wise to MIL-C-5015 have a failure rate about 40 times as great as MIL-C-26500 types, which are the most effectively sealed. In terms of less maintenance, and less connector down time, the advantage to be gained from using the best-sealed connectors, in applications where contamination is a problem, is consummately clear.

(3) The mechanical crimp termination is vastly superior to the solder termination.

(4) It is entirely fallacious to assume that the more environmentally sophisticated connectors need necessarily give more trouble from a "human" error standpoint. In fact, just the opposite is true in this study.

REVIEW: This appears to be a well-handled study with reasonable conclusions. The use of a failure rate in units of time rather than disconnects may not be too useful in view of the fact that some connectors were operated often and others seldom. Nevertheless the data are also given in a more raw form, although readily interpretable, so that independent conclusions may be drawn if desired. This article seems to steer clear of the current connector controversy. ##

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R E L I A B I L I T Y A B S T R A C T S A N D T E C H N I C A L R E V I E W S

TITLE: Quantized probability circuit design principles applied to linear circuits

AUTHORS: R. C. Burns and A. D. Lawson, Sperry Phoenix Company, Phoenix, Arizona

SOURCE: IEEE Transactions on Reliability, vol. R-13, June, 1964 (published December, 1964) pp. 16-28

PURPOSE: To explain quantized probability and compare it with other methods of circuit performance analysis.

ABSTRACT: A circuit analysis method for linear circuits is needed which will adequately predict circuit performance as a function of component tolerances. This paper describes a method which weights the component variation from its nominal value into one of three groups; the group assignment depends on how seriously the component variation affects over-all performance. If the ratio, fractional change in performance to fractional change in component parameter, is between 0.2 and 0.6 the parameter is considered second order. If it is larger it is first order and if smaller it is third order. The parameters are weighted according to their effect on the circuit performance as follows: (1) First-Order Weighting: Components whose parameter variations affect circuit operation critically are taken at end-of-life tolerance. (The end-of-life tolerance includes initial tolerance plus environmental change plus variation due to aging.) (2) Second-Order Weighting: Components whose parameters affect circuit operation to a limited extent are taken at initial (purchase) tolerances. (3) Third-Order Weighting: Components whose parameters have negligible effect on circuit operation are taken at nominal values. This technique, identified as the quantized probability design (QPD) method, is compared with the absolute worst case (AWC), the Taylor worst case (TWC), and the uniform probability (UP) methods. The QPD procedure is given, based on the circuit performance equation. Two linear circuit applications are presented and analyzed which show the effect each component will have on circuit performance.

A comparison of design methods shows that the quantized probability design predicts less amplifier gain variation. Actual experience has shown that a closer correlation exists with the quantized probability design method, and therefore its use for linear circuits is recommended. (Authors in part)

REVIEW: This is an exposition of the method and a useful comparison with some of the other methods. There are problems, however, some of which are discussed below.

1. The reason for designating the method as the "uniform

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

probability design method" is not clear, nor is the meaning of "uniform probability." Perhaps a name such as "propagation of variances" would have been more descriptive and self-explanatory.

2. In using the formula $T_y^2 = \sum_i [(\partial y/\partial x_i)\Delta x_i]^2$ it is important to keep in mind the fundamental limitations. (The authors' notation is used here: T_y is the tolerance on the performance expressed as $k\sigma_y$; Δx_i is the tolerance on the i th parameter x_i expressed as $k\sigma_i$; the k's must all be the same.) These limitations are:

(a) The Δx_i and T_y are all expressed as multiples of their own standard deviations. If fractional limits such as those for 1% tails are used the equation is likely not to be true. (It would only be true insofar as the Gaussian approximation was adequate for each variable. This point is discussed further in Review Serial Number 131.)

(b) The linear approximation is adequate.

(c) The variables are uncorrelated.

If some of the variables are correlated and (a) and (b) above still hold, then a correct expression is

$$T_y^2 = k^2 \text{ var } (y) =$$

$$\sum_i [(\partial y/\partial x_i)^2 k^2 \text{ var } (x_i)] + \sum_i \sum_j [(\partial y/\partial x_i)(\partial y/\partial x_j) k^2 \text{ cov}(x_i, x_j)],$$

where $\text{cov}(x_i, x_j)$ is the covariance of x_i and x_j (a measure of the correlation of x_i and x_j), and $\text{var}(x_i)$ is the variance of x_i.

3. The authors state that the quantized-probability method agrees better with experiment than the propagation of variances, yet the means for comparison are not at all clear. For example, if Gaussian distributions are assumed, and $\pm 2\sigma$ limits are taken, it is expected that about 5% of the units will fall outside the performance limits. If greater deviations, such as $\pm 3\sigma$, are used, the formula is much less accurate. Correspondence with the number of circuits actually having performance outside the limits would not be expected and would be difficult to determine.

4. The quantized probability method seems to require more calculation than the propagation of variances technique. Virtually all the calculations necessary for the latter must be done anyway, then comparisons are made, and finally the calculations are redone in another way. Arbitrary assumptions are introduced in addition. What then are the advantages of quantized probability

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vs. propagation of variances? If there are any, the paper certainly does not explain them well.

In the propagation of variances, the non-significant terms are "self-erasing," i.e., they contribute a negligible amount to the answer. If desired, the terms could be dropped from the formula.

5. A large part of the paper is consumed in finding and evaluating partial derivatives. This may have been done for illustrative purposes, but the reader should be advised that computer techniques are available and may be much simpler and cheaper for his situation. (In a private communication the first author has stated that this thought was edited out of the original paper.) ##

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ASQC Code 814

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: High reliability electronic parts as justified system cost elements

AUTHOR: John A. Connor, TRW Space Technology Laboratories, Redondo Beach, California

SOURCE: IEEE Transactions on Reliability, vol. R-13, June, 1964 (published December, 1964), pp. 29-32

PURPOSE: To discuss improvements in parts' failure rates vs. improvement of system failure rate and to mention the economic aspects of such improvement.

ABSTRACT: Improvement in system reliability is worth money in terms of decreased maintenance costs and fewer systems needed. This savings can be contrasted with the cost of improving parts reliability.

The relative decrease in system failure rate equals the relative decrease in failure rate of the improved parts times the fraction of failure rate that is being improved. The improvement in system failure rate is thus expressible in terms of improvement in individual parts failure rates; the costs can be compared to the improvement. After each reliability improvement the cost and savings due to another increment of improvement should be recalculated.

REVIEW: This is a reasonable paper although much of the essential material has undoubtedly appeared elsewhere in the course of time. The author uses failure rate as a measure of reliability, a not uncommon situation. This, of course, implicitly presumes either a mean failure rate (more properly, mean hazard function) or a constant hazard function (exponential assumption). The exponential assumption is quite usefully made in the predesign stage, although any redundancy effects must then be properly calculated. The paper will be of most value to newcomers to the field of reliability, although it may remind old-timers of a few things they have forgotten.

Some other papers dealing with the economic aspects of reliable systems have been covered by Abstracts and Reviews Serial Numbers 903, 1199, 1230, 1234, 1271, 1297, 1298, 1303, 1691, 1828, and 1834. ##

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ASQC Codes 552;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A quantitative analysis of semiconductor device failure rates as graphically indicated in Military Handbook 217

AUTHOR: Steven K. Morrison, Reliability Section, Components Division, IBM Corporation, Poughkeepsie, New York

SOURCE: IEEE Transactions on Reliability, vol. R-13, June, 1964 (published December, 1964), pp. 33-41

PURPOSE: To present a method which enables the user of graphic failure rate data to express the data algebraically, to check the validity of the graphs, and to use the results to predict behavior patterns.

ABSTRACT: A graphical presentation of semiconductor device failure rates is made in Figs. 13B and 14B of Mil-Hdbk-217. Equations fitted to those curves predict interesting properties. On the basis of the equations and assuming their validity, it may be concluded that: (1) extrapolating to room temperature from failure rates of devices stored at elevated temperatures is not likely to be meaningful; (2) there is a definite relationship between storage failure rate and failure rate in actual use (in the temperature range of interest); (3) the storage failure rate is large enough at normal storage temperatures so that, if semiconductor device failure rates influence the reliability of equipment in which they are used, they will contribute significantly to the finite storage life of the equipment; (4) there are some instances (as delineated earlier by equations), when increasing the number of semiconductor devices and dividing the load proportionately improves reliability, and there are other cases when it does not.

While the analysis makes no claim as to the validity or accuracy of Figs. 13B and 14B, the mathematics permits statements about conditions necessary to confirm the data. If the data are confirmed, then the conclusions presented should affect the initial determination of failure rates, rating in terms of power, inventory procedures, and the systems application of semiconductor devices. (Author in part)

REVIEW: While the algebra in the paper was not checked, it is presumed to be accurate. This is certainly an interesting exercise, but the utility of it is uncertain. One is reminded of the jeweler who set his clocks by the noon whistle while the whistle blower set his watch by the jeweler's clocks. However, the author in a private communication has pointed out that a means of checking the graphs is given in the paper (see p. 41, column 1, paragraphs 2 and 3). It is only when the graphs are found to be valid that they can be used to draw "physics-of-failure" conclusions. When such is the case the procedure can yield useful information on device failure rates as functions of various stresses. ##

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65 A11917

Serial Number 1912
ASQC Code 838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Digital circuit redundancy

AUTHOR: Rein Teoste, M. I. T. Lincoln Laboratory, Lexington, Massachusetts

SOURCE: IEEE Transactions on Reliability, vol. R-13, June, 1964 (published December, 1964), pp. 42-61

PURPOSE: To provide a survey of redundancy techniques.

ABSTRACT: While some original work is presented, this paper is mainly of the nature of a survey of redundancy techniques to date. Several redundancy techniques are described in detail with mathematical models for estimating reliability improvement. The methods are compared on the basis of reliability improvement, insofar as comparison is possible, and general comments are made about applications. The reliability equations for Moore-Shannon, majority, gate connector, and other redundancies, show that Moore-Shannon type of redundancy provides the best reliability improvement where it is applicable. An example of a Moore-Shannon redundant flip-flop shows that large reliability improvements can sometimes be obtained by applying redundancy to only the less reliable components, thus keeping the amount of redundancy to a minimum.

The redundancy techniques are based on the assumption that failures of components are statistically independent. This is a very important point, because the redundancy techniques provide no protection if failures depend on some common disturbance. (Author in part)

REVIEW: This is a summary paper on an intermediate level. (It is not suitable as an elementary tutorial paper.) It will be of use to those who have some acquaintance with the field and want to broaden it. Not all of the assumptions are explicitly stated and this can cause difficulties. For example, the extra parts are assumed not to interact in any way and the extra wiring is assumed to be 100% reliable. These assumptions can be most important.

One should be sure that the complete system is understood and analyzed when the benefits of redundancy are calculated. This may include people who have to make decisions and it may include as an "element" merely the possible interactions between other elements. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The abused concept of conditional failure rate

AUTHOR: A. Papoulis, Visiting Professor, University of California, Los Angeles, California (on leave from Polytechnic Institute of Brooklyn, Graduate Center, Farmingdale, New York)

SOURCE: IEEE Transactions on Reliability, vol. R-13, June, 1964 (published December, 1964), pp. 62-63 (letter to the editor)

PURPOSE: To discuss the hazard function (conditional failure rate).

ABSTRACT: The hazard function is not a probability density function (pdf) since the area under the curve $\longrightarrow \infty$ as $t \longrightarrow \infty$, where t represents time. The hazard function is the pdf divided by the fraction of survivors at time t.

REVIEW: The development in this letter appears to be correct, but the differences between the first and second meanings are not obvious. No examples of misuse of the term are cited, although apparently the author knows of many. Those who were confused and used the hazard function incorrectly may find this note of help.

One example in which the hazard function is incorrectly referred to as a density function is found in the following sentence on page 135 in [1]: "The hazard function h(t) of a probability distribution of time-to-failure is defined as the (conditional) probability density function of time-to-failure, given that the device has not failed prior to time t." However, the authors go on in the same paragraph to make the following statement: "... h(t) dt represents the proportion of a population of devices which have not failed prior to time t, but which do fail in the interval (t,t + dt)." This statement is a correct definition of the hazard function h(t), and should be used instead of the first statement quoted above.

In a private communication the second author of [1] has commented as follows. "The hazard function should have been defined as <u>the value</u>, when x = t, of g(x;t), the (conditional) probability density function of time-to-failure given that the device has not failed prior to time t. This (conditional) probability density function is

$$g(x;t) = f(x)/[1 - F(t)], \qquad x \geq t$$
$$= 0, \qquad x < t$$

whose integral with respect to x from $-\infty$ to ∞ is unity."

REFERENCE: [1] Reliability: Management, Methods, and Mathematics, David K. Lloyd and Myron Lipow, Prentice-Hall, Inc., 1962 ##

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Serial Number 1914
ASQC Codes 817;833;836;
837;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The methods of reliability engineering

AUTHOR: V.J. Bracha, Director, Product Assurance, Northrop Space Laboratories, Hawthorne, California

SOURCE: Machine Design, vol. 36, July 30, 1964, pp. 70-76

PURPOSE: To describe the methods of reliability engineering.

ABSTRACT: The first step in establishing a systematic approach to reliable system design is a clear definition of requirements. In system design and development, reliability competes with performance, cost, time, logistics, and obsolescence. Consequently, it is not possible to simultaneously maximize all of the desirable properties of a system.

A reliability, as well as performance factors, must be assigned to each subsystem in accordance with reasonably optimum plans for so doing. These assignments are reviewed during the course of the development. A functional block diagram is prepared, then a reliability diagram is drawn from it. Failure information is then appropriately combined from the reliability diagram. The effects of part failures on other system elements should be carefully considered. When this is done, areas may be apparent where redesign is necessary for high reliability or maintainability. Each circuit should be analyzed for the effect on performance of component variations. There are several methods of doing this, such as worst case and Monte Carlo. The use of Preferred Parts is most helpful. These have been selected on the basis of performance and life information available on them. Such use will benefit from the usual advantages of standardization. Design reviews at several steps are, of course, essential.

REVIEW: This is a good introduction to reliability engineering. It appears to be well balanced in many ways. It is recommended for those who need or want such an introduction. (There are no references.) A more extensive introduction is the SAE book "Reliability Control in Aerospace Equipment Development," which was covered by Abstracts and Reviews Serial Numbers 1593 through 1600.) ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A numerical rating system for choosing electrical connections

AUTHOR: Donald Fulton, Project Engineer, Rome Air Development Center, Research and Technology Division, Air Force Systems Command, Griffiss Air Force Base, New York

SOURCE: Machine Design, vol. 36, July 30, 1964, pp. 102-107

PURPOSE: To describe a rating system for electrical joints.

ABSTRACT: The rating system described in this paper is based on 350 x 10^9 connection operating hours and was performed by Hughes Aircraft for RADC. Factor weights are assigned as follows (all are rounded off to the nearest 0.01):

Factor	Soldered	Welded	Crimped	Wrapped
Reliability	.60	.60	.30	1.0
Design	.80	.75	.50	.20
Manufacturing	.55	.65	.85	.95
Maintenance	.63	.40	.50	.50

Application weights were assigned as follows:

	Reliability	Design	Manuf.	Maint.
1. Lab Stationary	.10	.25	.50	.15
2. Lab Stationary Support	.10	.20	.65	.05
3. Field Stationary	.10	.30	.40	.20
4. Field Mobile Prime	.15	.50	.25	.10

The Merit Index is obtained by summing over the factors for any combination of joint and application; the higher any number, the better it is. (Each joint is discussed in detail.)

The paper includes the following data on connection failure rates based on equipment reports:

Connection Type	Estimated Failure Rate (per 10^9 hr)	90 Per Cent Conf. Int. (per 10^9 hr)	Number of Failures	Total time (10^9 hr)
Solder	5.7	5.3 to 6.2	427	75
Resistance Weld	7.0	3.5 to 11	8	1.1
Crimp	16	7.0 to 28	6	0.37
Wire Wrap	0.0037	0.0020 to 0.011	1	270

REVIEW: A figure of merit for connection-type vs. application is a good idea. Apparently much effort and engineering judgment went into this one. Inevitably in such circumstances, some situations are

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

given more weight than others. This results in uncertainties in the values of the factors which are not negligible. For example, suppose there were an uncertainty of 20% in each factor. This would result in a minimum uncertainty of 10% in the figure of merit. The example in the text draws the conclusion that one method is superior, yet the total spread is about 10%. One might prefer to say that the analysis showed little difference and that the decision could be based on other factors not taken into account in the figure of merit.

Actually since there are only 16 cases shown in the article, it is feasible to calculate the figure of merit for each. Only three are outside the range of 0.66 ± 0.05. The two low ones are both for application 4 where easy field repair is essential. The highest and lowest are both for the wrapped connection and one is high and the other low for applications 2 and 4, respectively; the difference is due to the interchange in emphasis between design factors and manufacturing factors. The table is reproduced below with all figures rounded off to the nearest 0.01.

Application \ Type:	Soldered	Welded	Crimped	Wrapped
1	.63	.63	.66	.70
2	.61	.65	.71	.78
3	.65	.63	.62	.64
4	.69	.67	.56	.54

The claim for objectivity in the analysis by this method is only partially supported. There is still a large measure of subjectivity in the assignment of percentages and in the factors to consider. It is doubtful that the figure of merit here will ever be developed into a "precision design tool." The thirteen cases falling inside the range of 0.66 ± 0.05 are probably essentially the same; i.e., conditions not considered in the model and the arbitrariness of numerical assignments are more important than the differences.

See Abstracts and Reviews Serial Number 1609 and 1685 for other figure of merit schemes and Abstract and Review Serial Number 1670 for an evaluation by Bell Telephone Laboratories of joints for their purposes. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Environmental testing

AUTHOR: Israel Katz, Environmental Test Editor

SOURCE: Electromechanical Design, vol. 8, July, 1964, pp. 69-82

PURPOSE: To present a status report on environments and associated testing.

ABSTRACT: Most environments are now reasonably well catalogued and can be tested for. There are four general classes of environments: undersea, surface, atmosphere, space. Tables give typical values of necessary environmental parameters and characteristics for undersea, blowing snow, freezing rain, military and space vehicles. The remainder of the text is discussed under the headings: Environmental tests (test recommendations, environmental test aspects of microminiaturization, automation in environmental testing, safeguards for test personnel), Current developments in test equipment (High-energy shock testers, environmental test chambers, full-scale space simulators, deep space simulation, simulated zero G mass-separation facility, six degrees-of-motion shaker, rocket noise simulator, stabilized arc jet plasma radiation source, extreme combined environmental testing of materials and processes).

There are many other tables listing specifications and commonly used terms.

REVIEW: This is a good article and can be of use to people already in the field as well as to newcomers. While the data are more intensive in some areas than others, it is a natural condition and does not detract from the presentation. There is a buyers' guide list following the article which also may be quite useful.

This is one of nine articles in the "Systems Designer's Handbook." (Vol. 8, No. 7 of Electromechanical Design); high reliability is contingent upon good, sound, careful, intelligent, painstaking, and thorough design. Many of the articles will be of help to particular designers in achieving these objectives. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A common-sense approach to RFI filter reliability

AUTHORS: Charles M. Hewison and Harvey Goodell, Filter Division, Sprague Electric Company, North Adams, Massachusetts

SOURCE: Sprague Technical Paper No. TP-64-2, 10 pp., originally presented before the Professional Group on Component Parts, Los Angeles Section, IEEE, Los Angeles, California, November, 1963

PURPOSE: To discuss the reliability of Sprague RFI filters.

ABSTRACT: The failure rate of the filter is calculated as the sum of the failure rates of the parts. The capacitors are presumed to have a failure rate which varies as the 5th power of the voltage, doubles for each 8°C above 125°C, halves for each 15°C below 125°C, and is directly proportional to capacitance. The inductors and soldered joints are presumed to have fixed failure rates. The other elements are presumed to have insignificant failure rates. Care is taken in the areas of design, materials, fabrication and assembly, production methods and controls, inspection and testing, and application. (These are discussed more fully in the paper.)

REVIEW: The approach described here appears reasonable. There would appear to be little that is new in the methods of calculating failure rates or in the statistical models chosen. Likewise, the engineering care and attention to detail is customarily considered necessary for high reliability components. In parts of the paper the authors seem to imply that theirs is the "common sense" approach, as opposed to that of reliability engineers and statisticians. Common sense is a rather difficult concept to clearly define, and much of what reliability engineers and statisticians do would undoubtedly be considered by them to be dictated by "common sense."

In a private communication the first author has pointed out that other component manufacturers do not appear to use a system approach to calculate reliability levels of component parts, nor is there any other apparent approach for determining the reliability level during the design of a component. He has also stated that the authors did not intend to pit common sense against reliability engineers, but rather to show that common engineering methods and judgment can replace indiscriminate application of enormous test programs. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: POED--a method of evaluating system performance

AUTHORS: D. R. J. White, D. L. Scott, and R. N. Schulz, White Electromagnetics, Inc., Rockville, Maryland

SOURCE: IEEE Transactions on Engineering Management, vol. EM-10, December, 1963, pp. 177-182

PURPOSE: To present a method for assessing the value of a system.

ABSTRACT: POED (Performance Organization for Evaluation and Decision) is an evaluation and decision technique which permits computing performance of a device, equipment, system or system complex, compares and scores this performance against requirements or value judgments representing users' needs; and organizes results in a useful manner so that assessment of value is readily achieved. It is a basic ingredient for making decisions. POED permits comparing performance of dissimilar or competitive systems against several yardsticks representing different attributes of performance requirements. It also provides a means for determining sensitivity of a system to its constituents and for computing the confidence factor of results. Finally, POED provides a synthesis tool for optimizing systems in conceptual-, design-, operational-, or retrofit-stages.

The POED is accomplished by assigning a Figure-of-Merit (FOM) to each measure of performance at any given level; the FOM is a number between 0 (useless) and 1 (excellent). It is important that the relationships be developed from the system level down to the element level (rather than vice-versa). At any level, the net FOM equals the weighted geometric mean of the FOM's of each element on that level. This is continued upward until the FOM of the system is obtained. (Authors in part)

REVIEW: This appears to be a good technique and is reasonably well described. It is not unlike others that have appeared from time to time. The discussion of standard deviation is incomplete since it does not say how to calculate this number. The question of uncertainty in the final FOM and the resultant adequacy of a decision is discussed, however.

This type of quantitative decision-making is quite worthwhile even though it contains many arbitrary factors. It forces the decision-maker and evaluator into saying what he means and into meaning what he is thinking. ##

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Serial Number 1919
ASQC Codes 711;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: User to maker--give us reliable fluid systems

AUTHOR: Franklin D. Yeaple, Associate Editor

SOURCE: Product Engineering, vol. 34, December 23, 1963, pp. 59-62

PURPOSE: To discuss some of the current problems in the hydraulics industry.

ABSTRACT: Teflon hose is such a good insulator that charges can build up on the walls and cause dielectric breakdown of the hose. This is being cured by adding carbon to the inner layer or throughout the entire thickness.

While fire-resistant fluids remove the fire hazard, the phosphate esters tend to attack most any organic material in sight. Submarines have gone back to regular fluids because their fire hazards are slight.

The piston rods on hydraulic cylinders had several kinds of troubles: (1) A dual seal, with bleed-off between, has been adopted in some cases so that the oil doesn't leak into the water, and the water doesn't leak into the oil (p. 61, first column). (2) The threaded ends were very poor in fatigue unless the threads were made entirely by rolling (rather than cutting). With that source of failure removed, other parts of the rods which had been machined had to be revised. All machine marks should be parallel to the shaft axis. (3) The air cushioning was found to be faulty; the detective in this case was a high speed camera.

Ford Motor Company found by dogged persistence that suppliers could, if forced to, provide solenoid air valves that would last 10^7 cycles. Ford made them rebuild and retest the solenoid valves over and over.

Users are having the usual types of troubles in selecting and using hydraulic fluids. The Army, for example, on some of its earthmoving equipment wants to use engine lubricating oils in the hydraulic system instead of hydraulic oils. This is because the engine oils are readily available and tend to be used regardless of what is specified.

REVIEW: This is a good rundown on what is wrong, or new, with some parts of the hydraulics industry. This type of article can be very helpful in keeping even those with marginal concerns informed about industry problems and what is being done about them. ##

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Serial Number 1920
ASQC Codes 711;773

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Triaxial tensile stress fatigue testing

AUTHORS: G. Welter and J. A. Choquet, Strength and Materials Department, Ecole Polytechnique, Montreal, Canada

SOURCE: Welding Journal Research Supplement, vol. 42, pp. 565-s--570-s, December, 1963

PURPOSE: To describe equipment for triaxial tension fatigue tests.

ABSTRACT: The study of the elastic and plastic behavior of metallic materials under uniaxial static and fatigue loads has resulted in many useful engineering applications. More often, loads are such as to produce more complex stress distributions and a study of biaxial and triaxial states of stress as well as stress concentration has to be made, particularly under pulsating fatigue tensile stress.

This paper describes a procedure for zero-to-tension equal, direct and triaxial tensile stresses applied in fatigue on specimens together with experimental results which enabled the tracing of separate S-N curves for each of three structural materials: SAE 1020, A-302 Grade B and T-1 steels. The fatigue curves obtained for triaxial stress show a direct relation to the uniaxial fatigue life of each material tested.

The hydraulic machine can also be used for static tension testing, the cubic specimen under test being either under uniaxial, biaxial or triaxial tensile stresses.

The cubic specimen presents six threaded ends in three normal directions and is thus pulled in fatigue along its three principal planes, the biaxial and uniaxial specimens having geometrically similar four and two threaded ends, respectively.

Successive developments for automatic operation of the machine are also described together with another tension-compression triaxial fatigue testing machine operating on a similar principle. (Authors)

REVIEW: In every field, people are trying to find tests that are reasonably simple to analyze, yet correspond better to service conditions than the tests usually used. Triaxial fatigue tests are a case in point here. This paper is rather difficult for someone to understand unless he is well acquainted with these methods. Nevertheless, this type of work is important and this paper does demonstrate some of it. (The ordinate in Fig. 8 should be stress rather than strength.) ##

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4/65 G

Serial Number 1921
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: On cumulative damage in impulse fatigue tests

AUTHOR: S. Tanaka, Professor, Institute of High Speed Mechanics, Tohoku University, Sendai, Japan (present affiliation: The University of Electro-Communications, Tokyo, Japan)

SOURCE: Transactions of the ASME, Journal of Basic Engineering, vol. 85, Series D, pp. 535-538, December, 1963 (Paper No. 62-WA-17)
but see 65N27260

PURPOSE: To test Miner's theory of cumulative fatigue damage for impulse-induced damped vibrations.

ABSTRACT: A fatigue test was made for mild steel cantilever specimens subjected to repeated lateral impulse. There was a cumulative damage effect as a result of stresses arising from free-damped vibration of the specimen in the intervals between the repeated impulse: This cumulative damage is as predicted by Miner's hypothesis. These results have verified Crede's prediction of fatigue failure for a material subjected to repeated impulse. (Author)

REVIEW: The conclusion of the applicability of Miner's theory of linear cumulative damage is reasonably well borne out by the curves given in the paper. Of course, one deals only with the median curves and scatter is not considered. For many engineering purposes, linear damage theory is adequate since the data and models being used are not very accurate themselves. ##

63A17549

Serial Number 1922
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Assessing helicopter safety with respect to component fatigue

AUTHOR: A. D. Hall, Technical Department, Westland Aircraft Limited, Yeovil, England

SOURCE: Aircraft Engineering, vol. 35, pp. 97-99, April, 1963

PURPOSE: To discuss the prediction of safe operation with respect to fatigue.

ABSTRACT: It is not feasible now to get a complete load spectrum for every critical part in a helicopter. The load spectrum must be determined from some strain gage measurements and from analyses of flight parameters such as power and torque. These parameters can be related to loads in each part by other tests. The question then arises as to testing parts with a complete load spectrum, or to find the usual S-N curves, and calculate the life of a spectrum using some theory of cumulative damage. It is suggested in this paper that the latter is, all in all, the better way at present. Actually, S-N-P curves must be determined so that low probabilities of failure can be estimated. If a representative program type of test can be developed that is accurate and economical, it would have many advantages. A suggested probability of unsafe failure for the craft is 10^{-3} for a 10^{4}-hr operating life.

REVIEW: The author makes many valid points, although many are supported only by engineering judgment (this means that no one really knows and the engineer guesses as best he can). The statistical methods are stated rather loosely here, possibly because of lack of space. For example, all the formulas given for combining probabilities assume statistical independence of the associated events. This is often an unlikely situation. Also the author discusses failure probabilities of 10^{-5} for some parts; no one knows what the probability distribution is that far out on the tails. Engineering judgment should then be used to determine a reasonable safety margin--the failure probability cannot be calculated.

Unfortunately, in dealing with fatigue as with other facets of reliability, the scatter in the data is so great that statistical methods of some sort must be used. The only trouble is that there are rarely enough data to give designers the information they need. ##

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64N10858

Serial Number 1923
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Fatigue substantiation of helicopter components

AUTHOR: A. D. Hall, Technical Department, Westland Aircraft Limited, Yeovil, England

SOURCE: Aircraft Engineering, vol. 35, pp. 316-325, November, 1963

PURPOSE: To examine the part that metal fatigue plays in the engineering of a helicopter and to outline methods for predicting a safe part life.

ABSTRACT: Fatigue is the brittle-like failure of parts due to fluctuating, vibratory and cyclic stresses at levels appreciably below their ultimate strengths. Many parts in a helicopter are subject to this kind of loading. (These are detailed in the paper.) In flight-testing one must measure, as well as feasible, the actual loading spectrum of each part for each condition or maneuver. The spectrum of conditions and maneuvers is obtained from a conventional source (such as C.A.M.6). The next problem is to run fatigue tests to establish the S-N curve for the material or component. Rather than a mean S-N curve, some sort of "lower limit" curve is used which experience has shown to be adequate. Other safety factors must be applied to account for the many causes of fatigue which are neglected in a simple theory of part operation. Some discussion is given of the use of statistics in fatigue.

REVIEW: This is a good paper for those not quite familiar with the problems of fatigue in aircraft. The discussion is sufficiently non-technical so that it can be followed by the non-specialist in fatigue. The discussion of statistics assumes a log-normal distribution. The statistical methods are stated rather loosely, possibly for editorial reasons. (See also the comments in Review Serial Number 1922.) ##

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63A23955

Serial Number 1924
ASQC Codes 300;810;871

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability, quality control and maintenance

AUTHOR: -- Ray, W.

SOURCE: Aircraft Engineering, vol. 35, pp. 279-280, September, 1963

PURPOSE: To give the background to the reliability and quality control philosophy pursued during design and production of the Belfast, and some aspects of maintenance and servicing.

ABSTRACT: Even though there were no formal reliability requirements, it was decided to provide a reliability program in the development of the Belfast aircraft. Fortunately, many operating conditions were similar to those on other aircraft so that the experience could be transferred. A wider use of standard components would benefit reliability in the long run. The quality control efforts were extended to the design phase to ensure that the design itself was suitable for high reliability. Much attention was paid to the ease of maintenance and servicing (some details are given).

REVIEW: This is a rather general description of the philosophy and is more interesting than informative. ##

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63A15348

Serial Number 1925
ASQC Code 810

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability of aerospace electrical equipment--how much does it cost?

AUTHOR: J. A. Jennings, Jr., Westinghouse Electric Corporation, Lima, Ohio

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, February, 1963, pp. 38-40

PURPOSE: To discuss the management aspects of a reliability program.

ABSTRACT: Reliability theory, failure rate information, the use of reliability specifications, and other tools of a reliability organization have been widely discussed in trade and scientific journals. A number of useful references relating to those facets of reliability are appended to this paper. No attempt is made to discuss those details in this paper. The emphasis is on what the problem is; where it came from; and how to organize to meet it.

There have been numerous changes in component characteristics during the last five years. These changes have created many problems for both the designer and the user. The efforts of management, both private industry and government, to focus attention on these problems have created a new discipline, Reliability. This paper demonstrates that it is within the capability of every organization, large or small, to have a good reliability organization at a reasonable cost. Some key thoughts are:

1. No company can afford not to have a formal reliability organization.
2. The inauguration of a formal reliability program should not require a significant increase in personnel.
3. A violent reorganization is not required to make a company comply with DoD regulations. Minor reshuffling of functions or a secondary reporting structure may be adequate.
4. A closed-loop data reporting system is a mandatory part of a reliability program.
5. Finally, a cooperative attitude by management plus an "across-the-board" approach are the keystone of a successful program.

(Author in part)

REVIEW: This is a paper dealing with the management philosophy of a reliability program; as such, it is worthwhile. However, it does not explicitly discuss costs and in this respect the title is somewhat misleading. A key thought is a parenthetical remark by the author intended to show how everyone should eventually do his own reliability work: "The Utopian situation would have the reliability people work themselves out of a job." ##

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G

Serial Number 1926
ASQC Codes 711;716

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A method for estimating the thermal life expectancy of distribution transformers

AUTHOR: R. E. Rood, Westinghouse Electric Corporation, Sharon, Pennsylvania (present affiliation: Electrical Engineering Department, Tulane University, New Orleans, Louisiana 70118)

SOURCE: 11 pp., presented at the AIEE Winter General Meeting, New York, New York, January 27-February 1, 1963, IEEE Transactions Paper No. 63-241, available from IEEE, Post Office Box A, Lenox Hill Station, New York, New York 10021

PURPOSE: To calculate the loss of insulation life of transformers.

ABSTRACT: The maximum hot-spot temperature of a transformer is estimated from the loading profile (both daily and annual), from the ambient temperature profiles, and from the construction of the transformer. If a linear cumulative damage theory, and an Arrhenius law of aging is used, then it is a simple matter to calculate the cumulative loss of life of the transformer insulation for various conditions. The appropriate data were fed into a properly-programmed digital computer.

These results are essential to the determination of the economics of overloading transformers. Some of the results are:

1. The significant portion of the thermal aging occurring during an annual load cycle takes place over a relatively small portion of the annual cycle.
2. A large portion of this significant aging occurs during the annual peak load cycle.
3. Both the magnitude of the annual peak load and the shape of the annual peak load cycle must be considered in life expectancy calculations. (Author in part)

REVIEW: This analysis uses a fairly simple and common model for the cumulative damage to insulation. The answers are not unexpected, after looking at the steepness of the temperature vs damage rate curve. Just how accurate the model is, is of course not known, nor are there any experimental data given in the paper. For another paper on the life expectancy of transformers see Abstract and Review Serial Number 1859. ##

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Serial Number 1927 -1
ASQC Codes 711;714

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Stress-corrosion cracking

AUTHOR: T. P. Hoar, Department of Metallurgy, University of Cambridge, England

SOURCE: Corrosion, vol. 19, pp. 331t-338t, October, 1963

PURPOSE: To discuss stress-corrosion cracking from the viewpoint of one particular school of thought.

ABSTRACT: The author shows how, beginning with a search for a mechanism of brittle fracture in ductile materials, he has come to think that stress-corrosion "cracking" is not true cracking at all, in the sense of the sudden rupture of crack sides by brittle fracture or cleavage. Stress-corrosion cracking can be defined as "the rupture of metal, taking the form of cracks, that may occur under the conjoint influence of a corrosive environment and applied or residual stresses". According to either the mechanochemical mechanism or Logan's film-rupture mechanism, a stress-corrosion "crack" proceeds by metal dissolution at its narrow advancing edge, with very little dissolution of its sides; in fact, it is really an exceptionally deep and narrow fissure. Either of the "chemical" propagation mechanisms requires not brittle but ductile metal at the advancing edge of a crack; all the cases of stress-corrosion cracking known to the author are of materials that are macroscopically ductile. Fairly recently, the high-strength aluminum-zinc-magnesium alloys, heat treated to the condition where they are susceptible to chloride stress-corrosion cracking, have been shown to have soft, very ductile grain margins that slip long before the much harder, less ductile, grain interiors and the cracking is intergranular, apparently following the more ductile zone. The strong influence of plastic deformation of ductile material just ahead of a stress corrosion crack in promoting rapid dissolution of the advancing edge has also been accepted for a magnesium-base alloy by Priest and his colleagues and for copper-gold alloys by Robertson and Bakish. It begins to look as if the mechanism may be general.

Several other possible mechanisms are critically reviewed. The equally critical importance of the chemical nature of the environment is emphasized. This must be such that static metal dissolves very slowly, either because it becomes passivated or because it has an inherently very slow rate of active dissolution at the anode potential that operates, whereas yielding metal dissolves very rapidly, either by rupture of a passive film as emphasized by Logan or by the mechanochemical effect. In fact, stress-corrosion cracking can occur only when the metal has very particular properties and the solution a very particular composition. Further, the metal/solution interface must operate in a

particular range of potential difference, as now shown by Smialowska for carbon steel in nitrate solutions, and by the author and associates for austenitic stainless steel in chloride solutions and for brass in ammoniacal solutions. Quite possibly also, very easy adsorption of a component of the solution at the active metal/solution interface, as indicated, for instance, by Staicopolus for chloride ion on austenitic steels, is sometimes important in facilitating rapid mechanochemical or "film-rupture" dissolution. It is fortunate that at least three or four rather special conditions must be present simultaneously if stress-corrosion cracking is to occur.

There are 84 references. (Author in part)

REVIEW: Engineers and "reliability" engineers in particular need to become more familiar with metallurgical problems that may beset their hardware. This paper works well toward that end. The author accomplishes his purpose well and fairly. The discussion and review of alternative hypotheses contributes much to the paper. ##

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Serial Number 1928
ASQC Codes 711;714

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Implications of the stress aging yield phenomenon with regard to stress corrosion cracking

AUTHORS: P. R. Swann and H. W. Pickering, United States Steel Corporation, Edgar C. Bain Laboratory For Fundamental Research, Research Center, Monroeville, Pennsylvania

SOURCE: Corrosion, vol. 19, pp. 369t-372t, November, 1963

PURPOSE: To detect the stress-aging yield effect and to determine its implications relevant to stress-corrosion cracking.

ABSTRACT: From the experiments on austenitic stainless steels, Inconel, pure copper, copper-gold and magnesium-aluminum alloys it is concluded that:

1. The stress-aging yield phenomenon is observed in alloys susceptible to stress corrosion cracking and is associated with the segregation of solute atoms to dislocations.

2. The temperature of a stress corrosion test is high enough to allow diffusion of substitutional solute atoms to occur over short distances.

3. From observations of the Portevin-Le Chatelier effect, it is deduced that during a stress corrosion test, moving dislocations transport solute atoms to the free surface of a metal. In metals where slip is restricted to certain planes, the additive effect of many dislocations leaving the surface along the same line produces a large surface step whose surface composition varies greatly from that of the surrounding matrix.

4. The segregation of solute atoms at active slip planes containing a high density of dislocations, or at surface slip steps, produces the chemical inhomogeneity necessary to initiate and propagate a stress corrosion crack.

5. The segregation effect is expected to be more pronounced in a corrosion fatigue test, as this type of deformation creates many vacancies which accelerate the diffusion process. For similar specimens, corrosion fatigue should therefore occur at lower temperatures than stress-corrosion cracking. (Authors in part)

REVIEW: This is a "physics-of-failure" type paper as far as reliability is concerned. Those interested in stress-corrosion cracking will find this paper of importance.

(The discussion and reply at the end of the paper is most helpful.) ##

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Serial Number 1929
ASQC Codes 711;714;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Statistical distribution of stress corrosion endurance

AUTHORS: F. F. Booth, G. E. G. Tucker, Aluminium Laboratories, Limited, Banbury, Oxon, England and H. P. Godard, Aluminium Laboratories, Limited, Kingston, Ontario, Canada

SOURCE: Corrosion, vol. 19, pp. 390t-395t, November, 1963 (see also Errata in Corrosion, vol. 20, p. 178t, May, 1964)

PURPOSE: To analyze the statistics of stress corrosion lives.

ABSTRACT: This article describes a statistical analysis of certain stress corrosion endurances, made with a view to identifying the type of frequency distribution to which they belonged and hence to recommending appropriate methods of treatment of stress corrosion results. It was found that the logarithms of the endurances of stress corrosion specimens of aluminum alloys tested in salt peroxide solution are normally distributed and that the variance of the logarithm of endurance is independent of the mean but not constant. It was concluded that the most meaningful representative endurance is the geometric mean, of which the median is a good approximation.

Other estimates which may show a saving in testing time or cost can be found which are only slightly, if at all, less efficient than the geometric mean. These other estimates use linear functions of the logarithms of endurance in a censored (i.e, incompletely tested) sample. The relative merits of various procedures are discussed by way of example and the corresponding time savings are quoted using a standard deviation which is representative of the present results. The method of calculation is given in the Appendix so that it can be applied for other values of the standard deviation. It is recommended that reports of stress corrosion tests should quote all the individual values obtained, the estimated geometric mean endurance, the estimated standard deviation of the common logarithm of endurance, and the number of specimens removed from the test before failure, if any. In addition it would be useful to quote the lower 90 percent confidence limit for endurance. (Authors)

REVIEW: Where stress corrosion is a problem in the environment of equipment, this paper will be of use to designers. Of special importance is the introduction (in the last sentence of the ABSTRACT above) of a statistic other than a measure of central tendency. Designers in general are not interested in designing for 50% success and 50% failure, but for a very large proportion of successes. This type of work should be encouraged, especially more knowledge on the distribution shape at short lives. ##

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Serial Number 1930 -1
ASQC Codes 711;713;714

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Fundamental considerations of stress corrosion

AUTHOR: M. C. Huffstutler, Bell Telephone Laboratories, Inc., Murray Hill, New Jersey

SOURCE: Corrosion, vol. 19, pp. 423t-426t, December, 1963

PURPOSE: To discuss the fundamental aspects of stress corrosion.

ABSTRACT: There are many factors in the corrosion test or the environmental exposure which influence the prospects for stress corrosion of a given metal or alloy. The effects of stress upon electrode potential are small in comparison with measured corrosion potentials reported in the literature. Stress does play an important role through mechanical effects such as extension of cracks and electrochemical effects such as development of composition and structure fluctuations which may be anodic to the bulk material. In those cases where application of cathodic potentials can stop or retard stress corrosion, one might suspect that certain active regions within the alloy solid solution are responsible for the bulk of "stress corrosion." The tendency of certain systems for transgranular fracture may, indeed, be associated with the localization of solute elements within crystalline defects so as to produce localized cells which dissolve the more active areas, leading to crack propagation. In the case of systems which exhibit intergranular stress corrosion fracture the explanation is more complex and must take into account the equilibrium tendency for grain-boundary segregation of certain solute elements, and the tendency for massive precipitation of intermetallic compounds at the grain boundaries where the precipitation is more easily accommodated. Again, however, because of the relatively large stress corrosion potentials, the role of solid-solution activity variations cannot be ignored.

In the interest of planning experiments which will elucidate the mechanisms of stress corrosion, the requirements are clear. It must be possible to differentiate between the various structural characteristics which result in composition variations in the solid solution and to define the extent of the composition fluctuation within a particular type of defect. This suggests the use of single crystal test specimens with accurate measurement of the elastic stress level within the specimen. It is, of course, extremely important to define the corroding medium in terms of dissolved oxygen or other molecular gases and in terms of the activity of all the ionic species present. A detailed study of the morphology of the surface before and after corrosion, as well as of the characteristics of the films formed, is necessary in order to define any fundamental corrosion test. (Author in part)

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

REVIEW: This is a fundamental paper, not in the sense of being elementary, but in the sense of a close look at the foundations of the theory. It will be of more use to those doing research in the field than to design engineers who may desire an elementary discussion. ##

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64A15596
63A22899

Serial Number 1931
ASQC Code 824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Statistical analysis of transistor reliability tests

AUTHORS: V. L. Zmudikov and I. V. Petrushko

SOURCE: Automation and Remote Control (A translation of Avtomatika i Telemekhanika, a publication of the Academy of Sciences of the USSR), vol. 24, pp. 1040-1041, January, 1964 (Instrument Society of America, 530 William Penn Place, Pittsburgh 19, Pennsylvania)

PURPOSE: To find the minimum number of tests for evaluating failure probability.

ABSTRACT: The binomial failure probability p can be estimated by performing a series of N tests. If N is large, the uncertainty in p is Normally distributed. If $p = 1 - e^{-\lambda t}$, where λ is the assumed constant failure rate, then the error in p can be related to the uncertainty in λ. These calculations are shown.

REVIEW: In general, the problem of estimating parameters is well treated in the usual English-language literature. This analysis offers little, and is essentially a confusing approach to a straight-forward problem. ##

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Serial Number 1932
ASQC Codes 715;782;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability in spacecraft electronic wiring

AUTHOR: --

SOURCE: Missiles & Space, vol. 11, February, 1963, pp. 24-25

PURPOSE: To discuss wire insulation for spacecraft.

ABSTRACT: Some of the polymers with excellent vacuum and thermal properties make good dielectrics in the absence of radiation. However, they are easily degraded by space radiations.

Many of the olefin polymer structures do not have these disadvantages and are recommended for spacecraft use.

REVIEW: One table gives some of the effects of radiation on polymers although details of the tests are not given (vacuum or atmospheric pressure, temperature, etc.). In any event, a designer should have all the available pertinent data on the several possible dielectrics and then make his decision. Articles such as this are useful for drawing attention to little-known materials but of course, should not be used as a basis for design decisions. Details should be sought from appropriate sources. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Maintenance prevention is growing up

AUTHOR: (Editorial matter based on the report "A method of identifying, quantifying, and specifying the objective predictors of maintainability," by L. K. Brunner, L. K. Clevenger, and G. W. Dodson, School of Logistics, Air Force Institute of Technology, Air University, USAF, Wright-Patterson Air Force Base, Ohio)

SOURCE: Factory, vol. 121, January, 1963, pp. 68-71

PURPOSE: To summarize an Air Force report on designing for better maintainability.

ABSTRACT: One of the best ways to relieve the maintenance problem is to build equipment that needs less maintenance; another way is to build it so that the required maintenance is easily performed. The first relates to reliability, the second to maintainability. As systems become more complex, they tend to become less reliable --keeping things as simple as possible makes them more foolproof from design through use. Use parts that are known to have a low probability of failure for a reasonable time period. In some cases, having standby subsystems decreases the chance of system failure. Some parts tend to fail by wearing out and all have lives clustered around the mean life. Others seem to be as likely to fail at any one instant as any other. These two kinds require a different approach in design.

Several suggestions are given for improving maintainability.

REVIEW: This is an article better suited for those (such as managers) who need to be generally familiar with new words and concepts, rather than for those who must actually apply them. This is because many of the concepts are drastically oversimplified. As a paper to give to managers a concept which they did not have before, it serves its purpose well. ##

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4/65

63 A22295

Serial Number 1934
ASQC Codes 801;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Methods of solving the reliability problem

AUTHOR: W. B. Rossnagel, Reliability Manager, Aero-Space Division, Walter Kidde & Company, Inc., Belleville, New Jersey 07109

SOURCE: 4 pp., reprinted from Product Engineering, vol. 34, September 2, 1963

PURPOSE: To present some formulas and rules of thumb for reliability.

ABSTRACT: Some definitions of terms, reliability formulas based on the exponential distribution of time-to-failure, and reliability formulas for more than one unit are given. A nomograph is provided for solving the equation $R = \exp(-\lambda t)$. Recommendations for a reliability program are quoted from Mil-R-27542 and a simple stress-strength theory of failure is diagrammed. Testing to failure is recommended rather than testing to pass. Many Mil Stds., DoD Handbooks, reports, etc. on reliability are listed in this general summary.

REVIEW: This condensed collection of information is more suited as a reference or supplementary material than it is suited for learning from. For example, the formulas for combining reliabilities mention nothing about the basic, vital assumption of statistical independence of the events being combined.

The publisher's statement in the title that "Whether you buy or design for reliability these definitions and formulas can save you time and money" misstates the intent of this article considerably. ##

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62N14854

Serial Number 1935 -1
ASQC Codes 224;774

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Continuous sampling plans under destructive testing

AUTHOR: Frederick S. Hillier, Applied Mathematics and Statistics Laboratories, Stanford University, Stanford, California

SOURCE: Journal of the American Statistical Association, vol. 59, pp. 376-401, June, 1964; also Technical Report No. 60, 55 pp., July 9, 1962, Applied Mathematics and Statistics Laboratories, Stanford University, Stanford, California, Supported by the Army, Navy and Air Force under Contract Nonr-225(53) (NR-042-002) with the Office of Naval Research (NASA accession number N62-14854)

PURPOSE: To present continuous sampling plans designed especially for destructive testing.

ABSTRACT: The primary measure of effectiveness of practically all existing continuous sampling plans is the average outgoing quality limit or AOQL. To insure that the actual average outgoing quality does not exceed the AOQL, these plans stipulate that 100% inspection shall be used, with non-defective items replacing defective items, whenever incoming quality is found to be sufficiently poor. Unfortunately, there are a number of products or parts which require destructive testing in order to ascertain whether the item is defective or not. For such items, it is clearly not feasible to permit 100% inspection. Therefore, new continuous sampling plans designed especially for destructive testing seem to be needed.

The formulation presented in the paper takes into account the possibility that the process quality may deteriorate to an undesirable level. It uses certain a priori information about the relative likelihood of the possible patterns of process quality over time. It then improves upon this a priori information by a limited amount of sampling inspection in order to more reliably ascertain when action needs to be taken to reestablish the process quality at a desirable level. The resulting continuous sampling scheme is designed to approximate the procedure which would minimize the total expected cost and imputed cost, including the expected cost of inspection, the expected cost and imputed cost of clearing defective items for use, and the expected cost and imputed cost of investigating and adjusting the process in order to improve the process quality.

Following formulation of the problem, it is determined when the process should be adjusted if no inspections are permitted to supplement the a priori information. It is then determined when the additional information on the process quality level to be obtained from inspection justifies the additional cost of inspection. The continuous sampling plan arising out of the analysis is summarized, and the resulting operating characteristics are

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

presented. The use of the plan is illustrated. The conclusions are summarized, indicating the limitations and disadvantages of the proposed sampling scheme, as well as the important applications for which the plan has much to recommend it. (Author in part)

REVIEW: There are many situations in reliability testing in which considerable prior information is available regarding the quality and life expectancy of the item to be tested. Conventional testing plans in general do not take this prior information into account. However, when the cost of testing is extremely high, and/or when destructive testing is involved, one cannot afford the luxury of ignoring prior information about the process quality level. This leads to the problem of having valid means of taking this information into account with an appropriate degree of confidence. The present report is addressed to this problem as it relates to continuous sampling inspection. As the author has indicated, the model should serve as a reasonable approximation for most relevant applications and the proposed plan should be better for the situations to which it is applicable than those previously available. It also appears that the general approach used can be extended to many other models, as well as to applications outside the area of continuous sampling.

Other papers relevant to the use of prior information in reliability testing have been covered by Abstracts and Reviews Serial Numbers 1287, 1291, and 1852. ##

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Serial Number 1936
ASQC Codes 412;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Some inferences about gamma parameters with an application to a reliability problem

AUTHORS: M. M. Lentner and R. J. Buehler, Iowa State University

SOURCE: Journal of the American Statistical Association, vol. 58, pp. 670-677, September, 1963

PURPOSE: To present conditional distributions useful in making certain inferences about the scale parameters of two gamma distributions and to point out an application in life testing.

ABSTRACT: Lehmann and Scheffé have shown how to construct uniformly most powerful unbiased tests of certain hypotheses when the assumed distributions belong to an "exponential family." The present paper is concerned with particular cases which arise from independent gamma variates with scale parameters θ_1 and θ_2. Conditional distributions are given which are appropriate for testing $\gamma = \gamma_0$, where $\gamma = c_1/\theta_1 + c_2/\theta_2$. As an application, suppose that a series system has two dissimiliar components with expected lives θ_1 and θ_2. When component failures are exponentially distributed, so are system failures, the mean being $1/(1/\theta_1 + 1/\theta_2)$. From independent estimates of θ_1 and θ_2 confidence limits can be found for this mean, or for the probability of successful system operation up to any fixed "mission time." With appropriate restrictions, more general distributions including the Weibull can also be treated. (Authors)

REVIEW: This is a straightforward mathematical paper which deals effectively with the problem to which it is addressed. Relevant references are cited. The results are applied to one of the simplest possible systems: two components operating independently in series. For this system, the paper solves the problem of obtaining confidence limits on system reliability given data on the components. Obviously, however, there is a need to go beyond the work of this paper and solve the problem for the much more complex systems which are commonly encountered in practice. ##

Serial Number 1937
ASQC Code 090

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A supplement to Mendenhall's bibliography on life testing and related topics

AUTHOR: Zakkula Govindarajulu, Case Institute of Technology

SOURCE: Journal of the American Statistical Association, vol. 59, pp. 1231-1291, December, 1964

PURPOSE: To provide a bibliography on life testing and related topics covering the period January, 1958 to December, 1962.

ABSTRACT: In 1958 Mendenhall [1] published a bibliography on life testing and related topics, covering the period up to the end of 1957. The present work constitutes a listing of about 800 items concerned with statistical theory and methods applicable to the study of life characteristics of physical or biological bodies, which appeared between January, 1958 and December, 1962. Each reference is classified into one of ten categories (one of which is a "no classification" category). Several bibliographies are listed, and a list of periodicals and books searched is given.

REFERENCE: [1] Mendenhall, W., "A bibliography on life testing and related topics," Biometrika, vol. 45, pp. 521-543 (1958)

REVIEW: This is an extensive piece of work covering the principal periodicals on statistical theory and methods over a five-year period which ended over two years ago. Many engineering and trade journals would also have published relevant material during the period of coverage, but they are not included. Thus no claim for completeness in the published literature can be made. Similarly, it must be kept in mind that much relevant material has been published since the end of the coverage of this bibliography.

The usefulness of this listing for information retrieval purposes is limited by the fact that the classification categories are very broad. For example "system reliability," as interpreted by the author is not at all discriminating. (Incidentally, the category M which appears on pages 1274 and 1280 should be Q.) The reader familiar with the literature in this field will recognize a number of typographical errors, particularly in misspelled author's names (e.g. "Crohn" on page 1245 should read "Krohn"). ##

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Serial Number 1938
ASQC Code 833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: 65 steps to reliable transistor performance

AUTHOR: Clarence E. Jahnke, Missile Systems Division, Raytheon Company, Bedford, Massachusetts

SOURCE: Electrical Design News, vol. 8, July, 1963, pp. 92-93

PURPOSE: To summarize some facts to aid in the design of reliable transistor circuits.

ABSTRACT: Transistors by the nature of their construction are inherently reliable devices. They become unreliable only through improper manufacture and application.

This paper summarizes 65 facts to aid in the design of reliable transistor circuits. Although some of them are straightforward, they are very sensible and not always observed. The circuit design engineer who acts on these facts will realize the long life and high reliability inherent in the transistor.

The material is organized under the following headings:

- The spec sheet--read between the lines
- Thermal considerations--heat sinks and stability
- Voltage breakdown--predominant causes
- Switching applications--saturation, leakage, speed
- Frequency considerations--high and low
- The production phase--handle with care
- Other operating environment--military and space applications

(Author in part)

REVIEW: This article is a concise summary of facts and practices that can be useful to transistor circuit designers and others responsible for the selection and specification of transistors. Many of the statements are facts familiar to any person with a basic knowledge of transistors, and can serve only as a convenient checklist for the designer of transistor circuits. Other points are not so familiar, but are facts that should be considered in the design of reliable transistor circuits. The reader will undoubtedly feel that the less familiar statements suffer from brevity since they are made without explanation; however, a consideration of them will be instructive. This paper is especially recommended for periodic review by those who design transistor circuits only infrequently. ##

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Serial Number 1939
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Peening increases fatigue strength of welded aluminum

AUTHOR: G. E. Nordmark, Research Engineer, Alcoa Research Laboratories, New Kensington, Pennsylvania

SOURCE: Metal Progress, vol. 84, November, 1963, pp. 101-103

PURPOSE: To show that peening is better than thermal stress relief for improving the fatigue life of aluminum weldments.

ABSTRACT: Residual stresses are produced in weldments by local thermal expansion, plastic deformation and subsequent shrinkage on cooling. In the region near the weld, the resulting tensile residual stresses have a magnitude approaching the yield strength.

Welding stresses significantly reduce the fatigue strength of aluminum welds, particularly longitudinal butt welds. But because thermal treatments to relieve these stresses are impractical for many large welded assemblies, peening can and should be considered as an alternate method of improving the fatigue strength.

The fatigue strength of longitudinal butt welds in aluminum plates can be increased significantly by peening the weld and the heat affected zone. Because of surface compressive stresses introduced by peening, the improvement in fatigue life is greater than that produced by thermal stress relief. (Author in part)

REVIEW: This is a rather brief note on the results on a few specimens, but it should be of interest to those who specify aluminum fabrication. The limitations of the tests (few specimens, axial fatigue) should be kept in mind. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Correlation between destructive and non-destructive testing of a large steel casting

AUTHORS: A. H. Sully and J. D. Lavender, The British Steel Castings Research Association

SOURCE: Engineering Materials and Design, vol. 6, pp. 354-357, May, 1963

PURPOSE: To compare the results using non-destructive testing techniques with the results obtained from conventional destructive testing on a large steel casting.

ABSTRACT: It is sometimes extremely difficult and in some cases impossible for the steelfounder to ensure that the central regions of heavy castings consist of completely sound metal. Increasing use is being made of non-destructive testing and the sensitivity of some of these techniques, for example, ultrasonic testing, is such that very minor defects inside heavy sections of steel can be readily detected.

A scrapped three-ton steel casting was acquired for use in this comparison. Non-destructive tests (NDT) used were ultrasonics and radiography with both X rays and gamma rays. The destructive tests were on coupons cut from the casting. Measurements on them were made of Young's modulus, ultimate and yield tensile strengths, elongation and reduction of area, and Izod impact.

The results show that impact and tensile properties are affected only slightly by microporosity; ductility is affected more, but without practical significance for the casting as a whole.

This investigation clearly demonstrates that care must be exercised in applying non-destructive tests of high sensitivity to steel castings and, in particular, in setting standards of acceptance based on these tests. The achievement of complete soundness in the central region of a steel casting of heavy section is theoretically possible, but, in practice, is extremely difficult and may require very expensive modifications to foundry methods.

Modern techniques of inspection are so sensitive that vaguely worded requirements, such as 'The casting shall be radiographically sound', or 'The casting shall contain no defects detectable by ultrasonic examination', are not only meaningless in some cases, but commonly unjustified when the end use of the casting is taken into account. The customer and foundry should agree on the sensitivity of defect detection that is required. There is clearly a case for the establishment of standards for inspection which take into account the service to which the part will be put. (Authors in part)

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

REVIEW: It is fortunate when opportunities such as this one are taken advantage of, since the use of NDT is greatly strengthened and improved by them. The cautions about overspecification are particularly worthwhile since it is so easy for engineers to be on "the safe side." Good sound practice calls for specifying the important things accurately and properly and letting the unimportant things go. Good and reasonable specifications also encourage a producer to not ignore them as he may do when he thinks they are unreasonable. ##

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Serial Number 1941 -1
ASQC Codes 431;872

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The setting of maintenance tolerance limits

AUTHOR: A. Alan B. Pritsker, Director, Systems Analysis Group, Battelle Memorial Institute (Currently Associate Professor of Engineering, Arizona State University)

SOURCE: The Journal of Industrial Engineering, vol. 14, pp. 80-86, March-April, 1963

PURPOSE: To develop an analytical method for setting tolerance limits on system maintenance.

ABSTRACT: The model proposed in this paper is based on the following assumptions:

1. The system can be characterized by one continuous-valued variable.
2. The variable is measured at discrete equispaced times called check points.
3. The joint probability distributions of the variable can be computed. A correlation exists between past and present values of the variable.
4. The probability distribution of the consequences of maintenance actions is known, and after a maintenance action the behavior of the variable is statistically similar to the original behavior of the variable.
5. Cost of measurement (or, equivalently, cost of checking, inspection, etc.), cost of degraded system performance, and cost of maintenance activities can all be computed. Furthermore, cost of measurement and maintenance activities are not a function of the value of the variable while cost of degraded performance is a discrete function of the value of the variable.

The procedure described for setting maintenance tolerance limits is based on a fundamental renewal theorem. A cost equation is used as a basis for the rational determination of maintenance limits. The cost is a function of the unit costs of maintenance, degradation and checking. It is shown that the form of the cost equation is the same for the cases when the maintenance limits are above the degradation levels as well as when they are below the degradation levels.

As an example, maintenance tolerance limits are set on a stochastic difference equation which has the following properties:

1. Its statistical characteristics are a function of time (non-homogeneous).
2. The present value is only dependent on the immediate preceding value (Markov).
3. Its joint probability distribution functions are Gaussian.

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

In the last section of the article, a procedure for setting maintenance limits and checking intervals simultaneously is given. (Author in part)

REVIEW: This is a mathematical paper. The assumptions appear to be well stated and an example illustrates the results. While not all the mathematics was checked, it appears to be of high quality. The answers are not in a form that will easily be used by design engineers.

Assumption 4 (the latter half) may be quite restrictive. It implies the exponential distribution of time-to-failure for the individual elements which are not subjected to maintenance action.

See also [1] in which the conditions for a maintenance interval of "infinity" are derived (i.e, no maintenance is best.)

REFERENCE: [1] "No-test, no-maintenance economics," by Robert L. Ferguson, IEEE Transactions on Aerospace, vol. AS-1, August, 1963, pp. 889-898 ##

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Serial Number 1942
ASQC Codes 843;872

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The Monte Carlo approach to setting maintenance tolerance limits

AUTHOR: A. Alan B. Pritsker, Associate Professor, Arizona State University

SOURCE: The Journal of Industrial Engineering, vol. 14, pp. 115-119, May-June, 1963

PURPOSE: To give a Monte Carlo approach to the setting of maintenance tolerance limits.

ABSTRACT: This is an extension of an earlier paper (see Abstract and Review Serial Number 1941) wherein analytical techniques were used for setting tolerance limits on system maintenance.

A solution by the Monte Carlo method is proposed to relax the assumptions that maintenance action returned the system to "as good as new condition" and the unit cost of degradation could be represented as a discrete function of the system variable required in an analytical procedure for setting maintenance limits. The criteria used are the costs associated with both degraded performance and maintenance action over the operational life of the system. It is assumed that a description of the operation of the system is available and that the effects of maintenance action are known.

The results obtained by the Monte Carlo Method apply only to the specific case because of its experimental nature; it does not have the generality of an analytical approach. However, the Monte Carlo Approach offers the following flexibility in the assumptions about the control process:

1. It can handle any form of stochastic description of the measured quantity.
2. It can handle any cost function (it need not be differentiable).
3. The limits need not be symmetrical.
4. It can handle various types of maintenance actions.

In addition, the Monte Carlo Approach can evaluate the effects of errors in estimating the description of the process.

Two examples are given and a simplified digital computer program is presented. (Author in part)

REVIEW: The approach here is quite satisfactory in principle. How easy it will be for a designer to use in practice depends on the ease with which the proper mathematical equations for the system can be developed. While the mathematics was not checked in detail, the paper appears to be of good quality. ##

4/65 64N16158 Serial Number 1943
ASQC Codes 770;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A realistic part-screening program for improving the reliability of space electronic equipment

AUTHOR: A. L. Heydrick, Electro-Mechanical Research, Inc., Post Office Box 3041, Sarasota, Florida

SOURCE: 5 pp., presented at the IEEE National Space Electronics Symposium, Miami Beach, October, 1963

PURPOSE: To describe a parts screening program for high-reliability systems.

ABSTRACT: This paper describes a part screening program designed to improve part reliability by weeding out early life failures, stabilizing part parameters, and eliminating parts with abnormal parameter drifts. It defines the tests performed, test conditions, accept-reject criteria and critical parameters to be monitored for each part type. It also includes a procedure for statistical analysis of recorded data and application of accept-reject criteria.

This program is not meant to be the ultimate answer to the elimination of unreliability in space electronics. However it has proved to be an effective method of implementing an improvement in part reliability. The program was developed as an economical and time saving approach to improving part reliability. (Author in part)

REVIEW: The paper does a good job of briefly describing the program. While the exact nature of the program is subject to some criticism as being "unproved", it does appear to be in line with sound engineering judgment. Most of the time, this is about all we can ask. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability science and technology in military and industrial contexts

AUTHOR: David S. Stoller, The RAND Corporation, 1700 Main Street, Santa Monica, California 90406

SOURCE: 9 pp., presented at the 24th National Meeting of the Operations Research Society of America, Seattle, Washington, November 7-8, 1963 (P-2802, The RAND Corporation, 1963)

PURPOSE: To discuss the characteristics of reliability as a scientific and technical field.

ABSTRACT: The phenomenon of reliability is a significant factor in a great many of the activities of a military organization. For example, if we study the operations which are involved in four major functions of a military aircraft squadron, namely, operations, maintenance, supply, and personnel, we see that reliability plays an important role in every one.

Suppose, however, we are studying the activities of an industrial organization. Although factors such as lethality and vulnerability do not carry over from military operations analysis into industrial operations analysis, other factors such as hostile actions (e.g., actions of competitors) and reliability clearly do. Naturally, reliability is not the only factor which must be considered, but it interacts with almost every other operational variable.

Major topics in reliability science and technology include:

1. The role of reliability as a basic parameter in systems.
2. The selection of meaningful and feasible levels of reliability for new designs or modifications, and the demonstration that these goals have been achieved.
3. The synthesis of estimates of reliability achieved or likely to be achieved.
4. The study of the impact on a system of various modes of equipment failure, with the view of protecting the system.
5. Those particular aspects of engineering management that pertain to reliability activities.
6. The study of the physical and field conditions for the end product.
7. Designing the system to satisfy conditions more severe than anticipated so as to obtain high reliability (safety factors).
8. The application and extrapolation of existing methods of reliability engineering practice.
9. The study of items which failed in test or use.
10. The information system implications of reliability engineering measurement, data systems, information flows.

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RELIABILITY ABSTRACTS
AND TECHNICAL REVIEWS

11. Fundamental research in areas which require long term investigation.

12. The acquisition, organization, and dissemination of reliability concepts, information, and applications. (Author in part)

REVIEW: This is a management-oriented paper designed to show that reliability is an important scientific and technical field. It was prepared as an oral presentation and was probably well suited to that purpose. With regard to item 7 (see ABSTRACT) it would seem more reasonable for the specifications to be generous relative to the estimated use conditions than for the design to be generous relative to the specifications. ##

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6

Serial Number 1945 -1
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Low-cycle fatigue

AUTHOR: --

SOURCE: Mechanical Engineering, vol. 85, May, 1963, pp. 40-43

PURPOSE: To review the approaches to low-cycle fatigue used by various industries.

ABSTRACT: Plastic straining is encountered in many engineering structures due to cyclic loading or cyclic thermal conditions. The straining is often magnified locally due to geometrical changes of section, thermal gradients, or joining of materials of different thermal expansion. As service temperatures rise and combinations of new materials are used, or, as new designs involving rapid shape changes are introduced, the overall strength requirements are met, but localized areas where low-cycle fatigue is encountered are often overlooked.

The difficulty of evaluating local areas of plastic straining and calculating thermally induced strain incompatibilities for all possible operating conditions has presented new problems to the mechanical engineer. General failure criteria, material data, and design procedures are not available. Three major categories of procedures are used for design: service experience, simulated service, and analytical approach. The only formalized low-cycle fatigue design is that for the naval reactor pressure vessel field. It uses specimen strain-cycling data, the maximum shear-strain theory, the modified Goodman diagram, linear cumulative damage, and theoretical strain concentration factors. The atomic energy industry uses similar approaches. Particular problems of importance to the atomic energy industry are: (1) the effect of mean stress on fatigue life, (2) the effect of biaxiality on fatigue life (this is particularly ill-defined in the case of thermal fatigue), (3) more data in general on various pressure vessel steels and fuel element core materials, and (4) the effect of environment including irradiation effects. The automotive industry uses service and simulated service when it can. In new areas it generally employs the analytical procedures above (with some changes). Ordnance and heavy equipment industries do not have an emphasis on the analytical approach even though their volume is rather small. There are no specific areas, but there is general agreement that more knowledge would be helpful. In ship structural design the approach is generally to avoid the problem where possible. There are several critical areas and problems needing further investigation. Brief comments are also made about the pressure vessel and chemical industry, design procedures for space and airframes, and the turbine industry.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

The committee felt that the foregoing approaches constitute an optimum utilization of existing information, but that the existing information is not sufficiently comprehensive to permit completely rational design procedures for low-cycle fatigue. Improvements in design procedures should be developed--especially as new operational requirements are faced--and these improvements will depend upon the generation of information in the following areas: effect of cyclic rate, initiation of a crack and its propagation, effect of wave shape, accumulated damage, combined stress, mean stress, strain concentrations, effect of metallurgical variables, effect of environment (irradiation, corrosion, vacuum, and so on) and combined fatigue, and susceptibility to catastrophic rupture.

This survey revealed many critical areas where our knowledge is insufficient and pointed out that no one area could be accepted on an industry-wide basis as "the" most critical area.

REVIEW: This is a survey paper covering "who does what?" and "who 'worries' about what?" in the field of low-cycle fatigue. As such it contains worthwhile general information. The paper does not have, nor was it intended to have, specific information for designers.
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65A18739

Serial Number 1946
ASQC Codes 782;833;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Correlation of ground, air and space failure rates

AUTHOR: C. M. Ryerson, Hughes Aircraft Company, Aerospace Group, Research and Development Division, Culver City, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 273-278

PURPOSE: To describe a new system of environmental failure rate adjustment factors developed by Hughes Aircraft Company.

ABSTRACT: This paper summarizes some results of a comprehensive survey and analysis of available failure rate information. The use of constant environmental adjustment factors for estimating the failure rate and/or MTBF for equipment used in other than a ground-based environment is considered to be unrealistic. A table of new adjustment factors is provided for many typical components. The values given in the table are based on a combination of actual test and use data plus engineering judgement. It is indicated that as additional data become available the factors will be modified.

Applications are made to an airborne radar power supply and an airborne radar computer unit. It is pointed out that the predicted MTBF's by the proposed method for these applications are more realistic than those obtained by methods given in MIL HDBK-217 or MIL-STD-756A.

REVIEW: This is a practical paper of value to the reliability engineer making standard failure rate predictions. The correlation between observed MTBF's and those estimated by using the new adjustment factors is useful. Attempts have also been made by some to derive expressions for failure rates as functions of stresses. See, for example, the many papers on models for accelerated testing, such as the one covered by Abstract and Review Serial Number 1216. ##

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65A18740

Serial Number 1947
ASQC Codes 770;815;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Status of German parts reliability

AUTHOR: F. Beyerlein, Siemens & Halske AG, Munich, Germany

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January 1965, pp. 279-284

PURPOSE: To describe the status of parts reliability in Germany.

ABSTRACT: The electrical or magnetic properties of a component are given by its structure, especially the physical and chemical fine-structure of the material used. If we look at drift failures we have to consider the relevant change of fine-structure and its influence on the values measured under the conditions of practical use. The relevant laws of physics and chemistry are the same all over the world, but there is a great difference in both the conditions of use and in the tolerance required.

In Germany, the number of components used for military purposes or for use in satellite guidance is low. Military electronic equipment is usually ordered from NATO members. The system of government contracts is only practiced in a small number of special cases, so that the manufacturing companies have to pay the cost of development themselves. A small number of companies are able and ready for fundamental research, and progress is being made in all fields of modern techniques. Technical developments in resistors and capacitors are described briefly. Reference is made to some German specifications incorporating reliability requirements (Standards DIN 41 400 with reliability figures, issued in 1941; DIN 40 040, a frame Standard on reliability, issued in 1960 and IEC/ACET(Germany)1, issued in 1961). Some practical considerations associated with testing are mentioned.

The German opinion is that one should try to obtain reliability figures from practical experience. Test conditions and relevant acceleration factors should be adapted to the expected failure rates. If a very low failure rate is necessary, testing is out of the question from a statistical viewpoint. The selection of a manufacturer with an established good reputation is the first step in getting good components. (Author in part)

REVIEW: This paper presents a brief picture of the status of parts reliability in Germany. It formed part of the international flavor which was planned for this symposium. It seems that discussions on reliability have not received as much attention in Germany as they have in the USA. This is understandable, since a great deal of the impetus in this country has come from the military preparedness and space exploration programs, which involve a wide range of manufacturers of components and systems. ##

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65 N19741

Serial Number 1948
ASQC Codes 817;838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Part reliability versus redundancy trade-offs

AUTHOR: Marvin H. Walker, Jr., Electro-Mechanical Research, Inc., Sarasota, Florida

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 285-292

PURPOSE: To give the basis for a comparison of non-redundant, parallel-redundant and quad-redundant systems and some results.

ABSTRACT: Two approaches can be taken to achieve high reliability in the design of electronic digital equipment: (1) redundancy of parts and systems, and (2) highly reliable burned-in and screened parts. This paper shows how to conduct a trade-off study using different degrees of redundancy and grades of parts to meet specified reliability requirements. Size and weight considerations are included in these trade-off studies. A hypothetical spacecraft pulse code modulation (PCM) telemeter is used to illustrate results of a reliability trade-off study. In this case study, quad part redundancy is more reliable than parallel system redundancy, which in turn is more reliable than a non redundant system. However, significant penalties are incurred in size and weight for the redundancy incorporated. The use of more reliable parts also offers significant gains in reliability for the different design configurations under study. The penalty here is in the increased cost of higher quality parts. (Author in part)

REVIEW: This is an example of a quick method for initial study purposes. The approximations generally appear to be both reasonable and adequately explained. The reader should be careful, of course, about blindly using the methods and approximations; their appropriateness for the case at hand should always be checked.
##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Determination and application of aging mechanisms data in accelerated testing of selected semiconductors, capacitors and resistors

AUTHORS: G. E. Best, G. R. Bretts, H. T. McLean, and H. M. Lampert, Spacecraft Department, General Electric Company, Philadelphia, Pennsylvania

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 293-302

PURPOSE: To present results of development programs for accelerated tests of some high-volume electronic parts.

ABSTRACT: Thermal and voltage acceleration of aging reactions in a lead-alumino-silicate glass dielectric capacitor, silicon alloy-junction diodes, silicon planar passivated transistors and metal and oxide film resistors are described.

The results reported are preliminary. The emphasis is on the failure mechanisms study portion of the accelerated testing program and the effort to provide data and information for test planning and analysis from physical data and principles.

Resistance change is plotted against the Larson-Miller (time-temperature) parameter for film resistors of both Evanohm and tin oxide. The time-temperature parameter is derived from fundamental reaction rate considerations.

Glass capacitors have two different modes of failure--at the electrode ends, or in the uniform region. The failure mechanism appears to be rather complex and includes both reversible and irreversible reactions.

Considering the amount of semiconductor testing performed, both at operating and accelerated stresses, there is very little published information which specifically relates stress levels, the drift behavior encountered, and particularly the responsible mechanism. The Atalla model of surface charge effects is believed to be applicable to observed test behavior. The concept that best fitted both the behavior patterns and failure analysis data was an accumulation of contamination within the package which, for the existing thermal distributions and electric field conditions at the die surface, established an equilibrium condition between the die surface and the package ambient. Then the diode behavior above 200°C could be attributed to a "gettering" reaction with package elements, such as the copper sheath of the dumet lead, which reduces the contaminant concentration in the package. The final contaminant is presumed to be a phosphorus compound. Ex-

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

periments are underway to determine the contribution of semiconductor temperature, junction bias and source concentration by exposing planar devices to an atmosphere containing phosphides supplied by an external source. (Authors in part)

REVIEW: Most of the material on resistors and the time-temperature parameter, θ, is taken (or copied) from Reference [4] in the paper (which was covered by Abstract and Review Serial Number 1456). The equation which is derived for θ does not correspond to the straight line observed for the data, as mentioned in the earlier review. A procedure is given for calculating θ in step-stress tests, but it is not justified in any way.

The discussion of failure mechanics for glass capacitors and for semiconductors is good although on semiconductors it is specifically limited to a few cases. ##

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Serial Number 1950
ASQC Codes 825;833;836

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Syncom reliability

AUTHORS: E. J. Althaus and J. C. Meyer, Space Systems Division, Hughes Aircraft Company, Culver City, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 303-312

PURPOSE: To present a case-history report on the reliability of the Syncom satellite.

ABSTRACT: Syncom 2 has demonstrated the feasibility of using synchronous orbit satellites as a practical and economical means of attaining world-wide communications. The success of the Syncom 2 satellite can be attributed to the following:

1. The basic simplicity of design of the spin-stabilized satellite, which required no moving parts other than the solenoid valves used in the reaction control system.
2. A rigorous test program that revealed problem areas early enough in the program to allow effective changes.
3. A parts program that provided screening that resulted in only high quality parts for flight spacecraft plus the fact that only "proven" parts were used in the design.
4. Effective use of design reviews.
5. A closed loop trouble/failure reporting system.

After more than one year of operation in orbit there have been no failures in any of the Syncom 2 subsystems. The only degradation has been in the solar array and this has followed the prelaunch predictions. This absence of failures in orbit when compared to the troubles that occurred during testing over a comparable span of time, but with considerably less operating time, indicates that the space environment at 22,000 miles is quite suitable for long life. This is possibly due to the absence of people handling the equipment and the completely vibration- and atmosphere-free environment in space. (Authors in part)

REVIEW: This is a good case-history report on the reliability of a specific spacecraft system--the Syncom satellite. The principal features are treated in reasonable detail and supporting data are given. The success achieved by the satellite is evidence of the effectiveness of the approach, the principles of which should be applicable in the design and development of other systems. The first author, in a private communication, has indicated that, as of January, 1965 the Syncom 2 satellite had operated over 17 months, during which time there had been one failure of a transistor in a redundant encoder. This failure was obviated by a method of hand reduction of the telemetered information. There have been no failures in the communications portion of the satellite. ##

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5/65 65 A18744 Serial Number 1951 -1
ASQC Code 824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The status of reliability assessment for unmanned satellites

AUTHOR: William Wolman, National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 313-319

PURPOSE: To discuss reliability assessment with particular emphasis on Goddard's space experience.

ABSTRACT: Reliability assessment techniques applied to Goddard's unmanned space systems now have been in effect for about five years and it is useful to review the methodology used, its effectiveness and usefulness. Such a review encompasses not only the approach and methodology which has been used but also a comparison of the assessment results prior to space flight with actual flight results. Major problem areas are the development of adequate mathematical models, the availability of information to estimate system, subsystem, component and part failure rates, the use of "correction" factors to compensate for the space environment and the proper interpretation of assessment results.

The performance of assessments before actual flight is discussed from the viewpoint of establishing a plausible hypothesis which is subject to acceptance or rejection by the flight program. The question of interpreting a situation where assessment results show a relatively unreliable system but later flight results show success or the opposite is examined in the framework of scientific and rational models.

The following conclusions and recommendations are given:

1. Reliability assessment is a useful technique especially in the evaluation of alternative design approaches, the pinpointing of areas of unreliability, and to give management an order of magnitude of the reliability of a system.
2. Assessment results should be used very cautiously to predict operational reliability before flight history has been obtained.
3. Much remains to be done in developing techniques for the analytical representation of complex systems as mathematical models.
4. Data inputs such as part failure rates used in system assessments are often inadequate due to lack of test knowledge, effect of interaction and unknown environment. The same can be said for "K-factors". (Author in part)

REVIEW: This is an expository paper on reliability assessment for space systems. It does not go into technical details or specific

methods, but does give some references in which these may be found. It serves essentially to convey a sound picture of the underlying philosophy. In particular, it includes a realistic discussion of mathematical modeling in reliability assessment studies. ##

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Assessing reliability growth potential

AUTHOR: Carl J. Napolitano, International Business Machines Corporation, Space Guidance Center, Owego, New York

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 320-323

PURPOSE: To describe a technique for assessing the reliability growth potential of a product as an aid in determining the level of reliability that is realistically achievable under specified time and cost constraints.

ABSTRACT: Growth in product reliability is accomplished throughout the product's life cycle by performing reliability activities which detect and localize existing and/or potential problem areas and provide appropriate corrective action. To ensure a successful program of reliability activities, product growth potential must be assessed to determine the feasibility of (1) attaining the required level of reliability, (2) at the prescribed imposition date, (3) under specified cost constraints. Three typical situations that may be uncovered by an effective assessment are: (a) insufficient growth requiring additional product improvement at consumer and/or producer expense, (b) suitable growth to achieve requirements at reasonable cost, and (c) over-abundant growth resulting in excessive reliability cost to the consumer. These are depicted by growth curves representing the reliability expected at various points in the life cycle. The curves are based on estimates of maximum reliability attainable within existing state-of-the-art limitations and the quality and quantity of reliability effort expended up to that time by various functional groups. This paper is concerned with a method for quantifying these factors from extrapolations of data on similar products to numerically assess growth potential.

The growth curve, a plot of anticipated reliability against program time, is based on an equation which expresses anticipated MTBF as the product of the maximum MTBF and the growth factor. The input quantities are empirically determined; they are explained and illustrated in the paper. A reliability growth curve for a simplex space exploration guidance computer (SEGC) being developed is described and interpreted to demonstrate the applicability of this technique. (Author in part)

REVIEW: This paper describes a reasonable approach to the assessment of reliability growth potential. As the author has indicated, it utilizes the law of averages in extrapolating data on reliability accomplishments in other programs. Obviously the quality of the results obtained in any application of the technique is dependent

on the validity of the input data and their pertinence to the situation under consideration. This point should be kept firmly in mind. The author has not overlooked it, as he states that the technique does not represent the ultimate in growth potential assessment, but that as more information becomes available on other programs, the method should give reasonably good estimates of growth potential. ##

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Serial Number 1953
ASQC Codes 813;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability of Minuteman operational ground equipment

AUTHOR: F. D. Pace, Aero-Space Division, The Boeing Company, Seattle, Washington

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 324-330

PURPOSE: To outline some of the reliability problems in the development of the Minuteman Weapon System, and some of the features of the program developed to solve them.

ABSTRACT: The Minuteman Weapon System is characterized by vast distances separating unmanned launch facilities, launch control facilities, and the single central wing manned maintenance facility in each wing. Since the survival of the missile depends upon proper operation of electric power, environmental control, and monitoring equipment, the reliability of ground equipment is equally as important as that of flight hardware. In order to meet operational requirements at reasonable maintenance cost, extremely high equipment reliability was required.

Part of the solution of this problem was an aggressive electronic parts improvement program aimed at achieving a significant improvement in the reliability of certain high-use electronic parts. This was accomplished by strict process and production controls implemented by suppliers, and by the identification and elimination of specific modes of failure. The use of redundancy was discarded and attention was focused on simplicity and high inherent reliability of equipment. Constraints on the design of the electronic portion of the weapon system included: (a) stress on circuit simplicity, (b) maximum use of parts under improvement programs, (c) parts derating to levels of 25% to 50% of nominal, (d) maximum use of solid state circuitry, (e) worst-case reliability analyses, and (f) reliability disciplines applied to subcontractors. Manufacturing controls included: (a) parameter drift screening, (b) environmentally controlled assembly areas, (c) extensive process controls during assembly, (d) a closed-loop data system, and (e) a comprehensive personnel training program. Detailed program plans were required on all major contracts. A complete launch and launch control facility was set up for testing purposes, to identify problems and isolate predominant modes of failure. The results of the program are summarized; supporting tables and graphs are included.

REVIEW: This is a good brief account of a reliability program which has achieved its objectives. The general principles on which it was based could undoubtedly be applied with success in other design and development programs. ##

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Serial Number 1954
ASQC Codes 872;882

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: System effectiveness--a new approach to reliability

AUTHORS: Stanley A. Rosenthal, Kollsman Instrument Corporation, Syosset, New York and Irwin Nathan, Aerospace Systems Division, General Precision, Inc., Wayne, New Jersey

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 331-344

PURPOSE: To present a survey and discussion of the system effectiveness approach to the achievement of system reliability.

ABSTRACT: Evaluation of the probability of achieving successful operation of a complex weapon system requires consideration of the joint effect of reliability, readiness, and performance parameters. System effectiveness modeling is discussed in this paper as a new approach to the achievement of system reliability. Earlier efforts in the development of system effectiveness models are surveyed, and the various factors affecting these models are reviewed and discussed. The growth of this concept is traced, highlighting some of the significant milestones in its development. Formulating system effectiveness models in terms of the various diverse factors allows evaluation of changes in design or operational conditions, thus enabling optimization of the probability of successful mission performance. The importance of this approach has recently culminated in the establishment of system effectiveness guidance groups in the Bureau of Naval Weapons and in the Air Force.

REVIEW: This is a readable survey of the development of system effectiveness; the references need to be consulted for details. It would be of interest to those initially looking into system effectiveness, but contains no new material. In addition to the two guidance groups cited in the paper, the Navy BuShips has a Systems Performance Effectiveness Steering Committee and a related program, with the lead laboratory located at the Applied Science Laboratory, Naval Base, Brooklyn, New York. Two books were recently published which primarily cover the topics of this paper; an applications viewpoint is used in [1], and a theoretical approach in [2].

REFERENCES:

[1] Sandler, G H., System Reliability Engineering. Prentice-Hall, 1963

[2] Barlow, R. E. and Proschan, F., Mathematical Theory of Reliability. Wiley, 1965 ##

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Serial Number 1955
ASQC Code 871

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Systems effectiveness in Bureau of Naval Weapons

AUTHORS: Captain J. N. Renfro, USN, and Mr. F. J. Schiavi, Research and Engineering Office, Washington, D. C.

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 345-356

PURPOSE: To describe the System Effectiveness Program in the Bureau of Naval Weapons.

ABSTRACT: A Bureau of Naval Weapons policy committee, with representation from the operating groups of the bureau, is responsible for policy, training, and techniques for improving reliability and maintainability. Plans for reliability and maintainability, with quantitative goals and check points, are established during system planning and are documented in the Technical Development Plan. Several of the programs aimed at better system effectiveness are illustrated. A Reliability Handbook (NAVWEPS 00-65-502) has been published which provides guidance for performing reliability program functions. Two reliability data exchange programs in the bureau are Interservice Data Exchange Program (IDEP) and Failure Rate Data Exchange Program (FARADA). Maintainability improvement programs include the requirement for a government and contractor maintenance management team, and an automated system for operational reliability and maintenance data. Examples of implementations of the system effectiveness program are cited.

REVIEW: This paper indicates that highest level personnel in BuWeps are involved in the system effectiveness program. Several of the specific illustrations are particularly worthy of note. According to the paper, contractors will be able to secure from a new data feedback system a continuous complete maintenance life history of equipments of their design, which is in sharp contrast to the prevailing situation where a military contractor often has no meaningful feedback data. The A7-A aircraft contracting arrangement has quantitative reliability and maintainability requirements, demonstration tests, and associated financial penalties for noncompliance; this is a strong incentive for contractor management to implement effective reliability and maintainability actions. Reliability management personnel who do business with BuWeps will want to be sure that they are familiar with the program elements which are cited.

Reference is made throughout the paper to slides by number, but the attached illustrations are not numbered. Apparently slide 13, which is cited in the paper, is not attached. Abbreviations are used in the text without definition, and the publications mentioned are not completely referenced. ##

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Serial Number 1956
ASQC Codes 817;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Correlation of system safety to system reliability

AUTHOR: Herbert J. Kolodner, System Safety Engineer, General Electric Company, Philadelphia, Pennsylvania

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 357-360

PURPOSE: To show how quantitative safety data can be obtained.

ABSTRACT: At some stage of most product design, a trade-off is required between System Reliability and System Safety. The condition can be equated to a teeter-board with Reliability on one side of the pivot point and Safety on the other. An increase in one is often accompanied by a decrease in the other. Due to the limitations imposed by weight, size, or cost, it is normally impossible to attain the ultimate degree of both requirements. Therefore, it is necessary to evaluate objectively each trade-off to ascertain its impact upon the system. Present methodology requires the attempt to correlate quantitative Reliability data with qualitative Safety data. Under these conditions, subjective reasoning becomes an intricate part of each decision.

The method involves the development of models for safety similar to those for reliability. Probabilities of unsafe conditions as a function of time need to be evaluated together with an analysis of the modes of unsafe failures and their effects. (Author in part)

REVIEW: This is an introductory discussion of the safety-reliability compromise; some of the terms may not be familiar to many readers. Although it is not explicitly mentioned, it would appear that the unsafe events are a subset of the unreliable events. It also appears that safety is defined as the probability of safe operation in analogy to reliability. It would seem that a general expression could have been written for safety when events may have various unsafe effects just as can be done for reliability when partial performance is considered. ##

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Serial Number 1957
ASQC Codes 836;837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Ion engine subsystem reliability procedure

AUTHOR: Vincent R. Lalli, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 361-379

PURPOSE: To describe a reliability procedure based on stress analysis which leads to an experimental safety-factor number

ABSTRACT: A question basic to the subject of reliability is that of finding a procedure which can be used to obtain equipment which will work when needed, under specified conditions, for as long as required. This paper describes a procedure that is being used for this purpose by the Reliability Office of NASA Lewis Research Center. Emphasis is placed on stress analysis leading to a number called the experimental safety factor. Knowledge of this number tells what margin of safety has been built into the apparatus. The procedure can be considered as a discipline for the engineering staff which requires that evidence be produced to show that equipment has been properly designed for all known stress conditions and contains adequate safety margins for transient use conditions. The engineering procedure for this reliability study can be divided into four categories: (1) modeling, (2) design review, (3) stress analysis, and (4) failure analysis.

Modeling is discussed briefly. Design review is described in some detail under the headings: circuit analysis report and packaging analysis report. Major emphasis in the paper is on stress analysis leading to the experimental safety factor. Failure reporting and analysis are described. A dot diagram developed to describe exhibited reliability as the project progressed is illustrated. The procedure was applied to an ion engine subsystem and worked quite well. Illustrative tables, charts, and figures are included in the paper. (Author in part)

REVIEW: This is a good and reasonably detailed account of the subject procedure. Evidence of the effectiveness of the procedure is provided by the successful flight of the engine subsystem to which it was applied. This paper should be of interest to design engineers, as the principles should be applicable to the design of other systems. ##

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Serial Number 1958 -1
ASQC Codes 300;813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Commercial reliability--the Chrysler 5 and 50 warranty

AUTHOR: F. Osann, General Plants Manager, Power Train Group, Chrysler Corporation, Detroit, Michigan

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 380-384

PURPOSE: To discuss the Chrysler Corporation automobile warranty.

ABSTRACT: The automobile buyer today is sophisticated and expects much from his car. Chrysler has responded with the 5-year/50,000-mile warranty on the power train. The problems of a commercial reliability program can be put into four categories: (1) the development of sound product design; (2) adequate control of the quality of materials and parts which come in from outside suppliers; (3) control of parts manufacturing processes within the company; and (4) control of assembly procedures. Although product design is separated from manufacturing for the purposes of discussion, the design engineers must in practice be constantly aware of the problems and requirements of manufacturing. It goes without saying that integrity of product design is essential to reliability, but this will not be achieved if proper liaison and information feedback between design, manufacturing, and quality control are not maintained.

Any design solution must of course be compatible with product cost objectives. The obvious solution may impose too great a cost penalty. So it is the responsibility of the designers, the product engineer, and the manufacturing organization to arrive at an economical solution as soon as possible. Where feasible, 100% non-destructive tests are a great aid, especially when they can replace destructive tests. Connecting rod bolts, for example, must be small to keep the engine small, yet must be strong enough. A failure can wreck an engine. If parts are selectively assembled, as in the power steering pump, a complete functional test must be used on the assembly.

Before we could grant our warranty we had to be sure of four things: (1) that we had sound engineering designs, proven out through rigorous testing; (2) that we had adequate control of supplier quality; (3) that we had control of our own parts manufacture, through the best possible production methods and rigorous inspection of vital parts; and (4) that we had adequate functional testing to check our own assembly procedures. Warranty cost trends are downward, and the quality control programs have more than paid for themselves. It is important to remember that quality begins (but does not end) at the top. The quality is no better than the manager wants it to be. (Author in part)

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

REVIEW: This is a relatively non-technical discussion of Chrysler's warranty. Other discussions of this warranty have appeared; see, for example, Abstract and Review Serial Number 1652.

For the other side of the picture (from the consumer's point of view), and for the automotive industry in general, Consumer Reports of April 1965 has an interesting discussion of what the expressed warranties and quality control are like as observed in new cars. For example, the expressed warranty is essentially only as good as the service you can get out of the dealer and the quality control tends to be pretty poor on many items; i.e., few cars are delivered without some noticeable defects.

While Chrysler Corporation rightly emphasizes their 5 and 50 warranty on the power train, they rarely mention that the rest of their guarantee is only half that of many other car manufacturers (1 and 12 instead of 2 and 24). Naturally, they feel that theirs is the more appropriate overall expressed warranty.
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Serial Number 1959 -1
ASQC Codes 813;814;836

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Commercial reliability programs--a good investment

AUTHORS: T. A. Daly and P. H. Ockerman, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania 15235

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 385-391

PURPOSE: To describe the Westinghouse commercial reliability program.

ABSTRACT: The economic impact of poor reliability of commercial products upon the customer and the producer is today receiving much closer attention by management, not only because the customer is becoming more reliability-conscious, but because the decision to establish an effective reliability program involves a financial investment which must be justified. Our reliability program was planned to fit into existing organizational structure with minimum disruption and expense, and to coordinate the efforts of present functional departments in achieving product and service reliability. Since a reliability effort as broad as this is a long-term growth program, much of the information on financial return will evolve in coming years.

A self-supporting reliability program should have overall customer satisfaction and appeal as its objective; thus its scope must cover all functions which bear on that objective (and all of them do) and it must have support from the top.

The following eleven points are important:

1. Institute and maintain in each division an aggressive program to improve and control reliability.
2. Assign responsibilities to each functional department for product reliability.
3. Establish reliability goals with measurable values assigned to elements affecting customer satisfaction.
4. Develop and formally review conceptual product designs to insure that they accurately reflect and incorporate customer reliability requirements, standardized components and simplicity of design, and performance data from factory and field.
5. Verify, through formal procedures, before releasing for volume manufacture, the design and performance of products and processes.
6. Control specifications and drawings to assure manufacture to current design information.
7. Establish and operate quality control procedures to assure conformance with engineering specifications.
8. Encourage suppliers to participate in the Westinghouse reliability effort, and purchase from those suppliers who consistently provide reliable material and components.

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9. Audit the reliability program by conducting reliability testing on each product and assimilating significant product performance data from factory and field.

10. Train each employee in the reliability techniques important to his job.

11. Maintain at the corporate level a reliability research and advisory function to increase the reliability potential of the corporation.

This type of effort does not cost, it pays. Fewer sales are lost because of dissatisfied customers, fewer dollars go into crash programs to lick faults found in production or the field, etc. Design reviews are especially important because of the tremendous cost of faults in design once they get frozen into production. (Author in part)

REVIEW: This is a rather comprehensive review of the Westinghouse commercial reliability program. As presented here, the program appears to be quite effective. Just how effective it is in all divisions and from the customer's point of view is not known. The emphasis on review, both with regard to the design itself and to the production processes for achieving the design, is very good. Little emphasis is given to the problem of extending the express warranty on the products. The degree of protection given by the express warranty is often the only means a customer has of knowing just how seriously to take a manufacturer's claims of quality.

In a private communication the author has stated that the total product warranty cost for the Corporation for the year 1964 has been reduced 22 per cent, in the face of steadily increasing gross sales billed. ...this is due principally to the stress laid by the Reliability Program upon continuous monitoring of warranty costs and prompt correction of their causes.

Westinghouse reliability programs have been described elsewhere; see, for example, Abstracts and Reviews Serial Numbers 1601 and 1652. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A commercial product reliability program

AUTHOR: E. G. Lebre, Director of Quality Assurance, Raytheon Company, Executive Offices, Lexington, Massachusetts

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 392-397 (Essentially the same paper appeared in Product Engineering, vol. 35, April 13, 1964, pp. 75-78)

PURPOSE: To describe a reliability program for a microwave oven.

ABSTRACT: Some general principles were established from experience with a microwave oven improvement program. These are:

1. The cost of either reliability or corrective action programs is to be paid from funds allocated for warranty expenses.
2. Product costs must not increase more than the warranty expenses predicted to be saved. Preferably, they should decrease.
3. The warranty expense budget is to be controlled by the Quality Assurance function.
4. The training, direction, and administration of field service personnel are to be the responsibility of the Quality Assurance function.
5. An efficient failure-data collection, analysis and corrective-action system is to be sustained.
6. A limited number of corrective action programs are to be undertaken. This can be done using an ordered distribution of warranty expenses for particular failure causes.
7. A minimum savings goal is to be established for each corrective action program considered.

While the program was based on military reliability efforts, there were some changes. One of the rather obvious economies was in the numbers of problems brought under consideration. Of nearly 25 failure groups, this program concentrated on the top four that accounted for approximately 62% of all warranty expenses. To date, the average annual warranty cost per equipment has been reduced by 80% and the other savings are tremendous.

Reliability programs do pay for themselves if the engineers are properly cost-conscious and attack the most pressing problems first.

REVIEW: It is encouraging to read of successful applications of reliability efforts to consumer and industrial projects. Many more of these should be started and perhaps papers such as this will help. It is especially encouraging to find that a product warranty has been extended. The express warranty is often the only means the customer has of separating extravagant sales claims from the real McCoy.

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R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

This paper will be useful for those who are interested in the problems and methods of others in a practical situation.

The fact that the author had published essentially the same paper some eight months before it was presented at this symposium (see SOURCE) is to be deplored. It would seem desirable for the symposium program committee to exercise greater care in their selections, especially when some worthwhile papers have to be turned down because of lack of space on the program or in the proceedings. ##

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G

Serial Number 1961
ASQC Codes 833;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability in commercialand

AUTHOR: George H. Ebel, Du Mont Laboratories, Division of Fairchild Camera and Instrument Corporation, Clifton, New Jersey

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 398-407

PURPOSE: To describe some experiences in commercial reliability.

ABSTRACT: If reliability pays, it should do so for commercial products as well as for the government. Two differences in commercial practice are that the economic justifications are more stringent and commercial parts vary all over the map. Engineers must realize that parts which have the same specs may not have the same circuit behavior unless the specs directly pertain to the performance in the circuit. Thus parts which are nominally the same may actually be different. It is well to pick out the most pressing problems and attack the most virulent of those, then go on to others as earlier problems are solved. This saves one from dissipating his resources. The physics-of-failure approach to parts comparison makes good sense.

REVIEW: The methods presented here seem quite reasonable for the type of operation discussed. They should be applicable to the manufacture of small equipment such as receivers and oscilloscopes. Many of the suggestions are "just good engineering" in situations where high quality is desired. The problem of parts specifications is an important one and an area in which great strides in reliability can be made. As the author points out, many times the important parameters of a part when used in a particular circuit are not specified; thus parts which are nominally the same can actually be quite different.

Many parts of this paper seem to be similar to the paper entitled "Physics of Failure in Commercialand" which was presented by the same author at the September 1964 Physics of Failure Conference. (Proceedings of that conference have not yet been published.) ##

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Serial Number 1962
ASQC Code 775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Nondestructive testing fundamental to advanced materials development

AUTHOR: John F. Judge, Associate Editor, Propulsion/Materials

SOURCE: missiles and rockets, vol. 16, February 22, 1965, pp. 27, 30, 32

PURPOSE: To present a feature story on the importance of nondestructive testing in the development of new materials.

ABSTRACT: Nondestructive test techniques have become a prime tool in the effort to produce materials capable of meeting the demands of future weapons and space systems. Once relegated to a mere inspection function, nondestructive testing (NDT) is now being used at Avco's Research and Advanced Development Division to quantitatively establish the nature and degree of variability in graphite destined for aerospace applications.

The key concept in the program is the attack on variability, which is considered to be the primary defect in almost all aerospace materials. The reasons for failure may be improper selection, application in design, fabrication or inspection. It is the material, however, that fails. Seeking the reasons for failure leads away from simple flaw detection to include all types of material variability.

There is no such thing as a universal method of NDT. The particular kind of test or combination of tests depends on the kind of variable and the kind of material. Proper selection requires experience and a working knowledge of the material. Some discussion of this point if given. A program plan is sketched, illustrating the flow of interactions from test choices through materials preparation to the correlation between material variability and nondestructive tests. (Author in part)

REVIEW: This article contains information of interest to design and development engineers on the potential value of NDT for quantitative properties measurement. NDT is assuming an increasingly important role in reliability programs--in this connection see the paper covered by Abstract and Review Serial Number 1897. An excellent feature article on NDT was covered by Abstract and Review Serial Number 1644. ##

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Serial Number 1963
ASQC Codes 822;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A method for discriminating between failure density functions used in reliability predictions

AUTHORS: Van B. Parr, Collins Radio Company, Dallas, Texas and J. T. Webster, Southern Methodist University, Dallas, Texas

SOURCE: Technometrics, vol. 7, pp. 1-10, February, 1965

PURPOSE: To present a technique based on the generalized gamma distribution for rejecting the Weibull and/or exponential functions when they do not appear to describe the failure density of the part in question.

ABSTRACT: Unless sufficient evidence to the contrary exists, the exponential distribution is often assumed as a model for the failure density function in reliability predictions.

The generalized gamma distribution, with known location parameter, is a three parameter distribution which encompasses the exponential, Weibull, gamma and many others. In this paper, (i) maximum likelihood estimation for the three parameters is indicated, (ii) it is noted that these estimators are asymptotically multivariate normally distributed, and (iii) using the distribution of the estimators, probability regions for the estimators of the parameters of the generalized gamma distribution are established for large sample situations.

In situations where the generalized gamma can be assumed as the correct density function, the exponential and the Weibull are special cases. A method is presented using experimental or life data for rejecting (with a known probability of false rejection) the Weibull and (or) the exponential functions when they do not appear to describe the failure density function of a unit. (Authors)

REVIEW: This is a mathematical paper which establishes results of practical usefulness in identifying the density function which best describes the time-to-failure of a component or system. The tendency to use the exponential density function without checking on its validity for the situation in question is all too prevalent. As the authors have indicated, this paper provides the reliability engineer with a method of determining when the exponential or Weibull should not be used. Its implementation will promote greater confidence in the accuracy of reliability predictions. ##

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Serial Number 1964
ASQC Codes 870;871

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Estimating maintenance float factors on the basis of reliability theory

AUTHOR: Boris Levine, Office, Chief of Engineers, U. S. Army

SOURCE: Industrial Quality Control, vol. 21, pp. 401-405, February, 1965

PURPOSE: To describe a simple and direct method of estimating the maintenance float factor, and to give some insight into the operation of a maintenance float.

ABSTRACT: One system for keeping important equipment operational is to use a maintenance float; a failed unit is replaced by one from the float and the failed unit is repaired and returned to the float. The size of the float must be adequate to the needs but should not be larger. This article proposes a simple analytic method for estimating the maintenance float factor. It assumes an "exponential" failure distribution and uses the ratio of repair time to mean time between failures (MTBF) as the variable. Estimates as to the need for float, its size and location can be made from the table and curves, or from the basic equation. (Author)

REVIEW: This paper accomplishes its purpose quite well. The mathematical development is straightforward and clearly presented. The accompanying discussion serves to illustrate the practical usefulness of the method, and to indicate that in some actual situations it has yielded quite good results. The analysis is based on an exponential distribution of time-to-failure, which makes it applicable to a wide class of cases of practical interest in reliability analysis. ##

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Serial Number 1965
ASQC Codes 760;770

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Flinching--a factor in estimating success probabilities

AUTHOR: David L. Field, Sandia Corporation, Albuquerque, New Mexico

SOURCE: Industrial Quality Control, vol. 21, pp. 406-408, February, 1965

PURPOSE: To discuss the problem of subjective bias in the interpretation and evaluation of the results of inspection and testing.

ABSTRACT: A major problem in estimating success probabilities is the interpretation and evaluation of the results of inspection and testing. If flinching occurs in the application of engineering judgement to these statistical situations, the resultant estimates may be heavily biased toward either extreme optimism or extreme pessimism. This paper briefly describes some of the principles often used in interpreting the results of inspection or testing, shows how flinching may occur, and sets forth some simple guide rules which should aid in the recognition of flinching when it does happen.

Various definitions of failure are cited, showing how different interpretations are possible, depending on whether the engineer takes a pessimistic or an optimistic view of the test results. It is indicated that rationalization in the interpretation of test results is often used instead of objective evaluation. Some key words which provide clues to flinching in the interpretation of test results are listed. "Murphy's Law" and seven "Fallerian Principles" are cited. It is concluded that careful analysis and evaluation of test results should precede any decision made on the basis of those results. (Author in part)

REVIEW: This is a good brief paper which conveys its message in an engaging manner. It will be well worth the thoughtful attention of those concerned with the interpretation of test results. In a somewhat similar vein, the paper covered by Abstract and Review Serial Number 913 discussed flinching in the reporting of human error under the title "Bowdlerization."

As a minor criticism, the author's definition of "random" given on page 407 in the paper is not the general one, but pertains to a special case. For the general definition, the words "an equal probability of occurring" should be replaced with "a definite probability of occurring." A random variable is one whose value depends on the outcome of a chance experiment, and the outcomes need not have "an equal probability of occurring." The definition in the paper pertains to the special case of a Poisson random variable. ##

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Serial Number 1966
ASQC Codes 300;810;814

300;810;814

810;813

821;850;853

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

G TITLE: Guaranteed reliability--Part I

AUTHOR: M. C. Haddon, Lockheed Aircraft Corporation

SOURCE: Industrial Quality Control, vol. 21, pp. 390-392, February, 1965

This is the same as the first part of the set of papers covered by Abstract and Review Serial Number 1652.

G TITLE: Guaranteed reliability--Part II

AUTHOR: H. E. Chesebrough, Chrysler Corporation

SOURCE: Industrial Quality Control, vol. 21, pp. 441-442, March, 1965

This is essentially the same as the second part of the set of papers covered by Abstract and Review Serial Number 1652.

G TITLE: Buick's reliability program

AUTHOR: J. R. Gretzinger, Buick Motor Division, Flint, Michigan

SOURCE: Industrial Quality Control, vol. 21, pp. 449-453, March, 1965

This paper is the same as the one covered by Abstract and Review Serial Number 1012.

65A21583

TITLE: A method of reliability estimates and demonstration data presentation

AUTHOR: Harold Gilmore, Avco Corporation, Wilmington, Massachusetts

SOURCE: Industrial Quality Control, vol. 21, pp. 505-508, April, 1965

This paper appeared in IEEE Transactions on Aerospace, vol. AS-1, August, 1963, and is covered by Abstract and Review Serial Number 1994. ##

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Serial Number 1967
ASQC Code 833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Connector feedback (a letter to the editor)

AUTHOR: W. P. Hart, Chief Reliability Engineer, ITT Cannon Electric Inc.

SOURCE: Evaluation Engineering, vol. 4, January/February, 1965 (in "Late Releases" inserted after front cover)

PURPOSE: To comment adversely on a previous article concerning tests for reliability of connectors.

ABSTRACT: The article prepared by one connector manufacturer (see Abstract and Review Serial Number 1846) attempted to discredit the position of the majority of connector as well as component manufacturers. It therefore seems appropriate that you should be aware of the following to have a complete and accurate position of the connector industry. The %/1000 hour failure rate is an industry standard used to evaluate many electronic components. Where one manufacturer agreed to accept the EIA Guidelines only if ingredients for a "%/cycle" approach were included, the majority of connector manufacturers would not have approved the Guidelines had they not contained the %/1000 hour failure rate.

Specific duty cycles relate directly to one application and do not relate to standard life environments for general purpose components. Actually, to take the duty cycle approach to its logical conclusion would suggest that each and every application should have its own reliability test and possibly its own connector. As far as "penalties" incurred by the %/1000 hour failure rate are concerned, a well designed %/1000 hour failure rate test program can be performed at a cost equal to or less than most cyclic tests, and such programs take approximately one year, not years as suggested in the article.

The risks alluded to are nowhere as great as the risk of cutting the stress of time, particularly in critical environments. The cyclic test of 6 hours originally included in the EIA Guidelines (but since removed) is meaningless for an application requiring thousands of hours of failure-free operation under critical conditions. And no amount of legitimate extrapolation can produce accurate information. (Author in part)

REVIEW: As mentioned in Review Serial Number 1846, this is an industry-wide controversy involving millions of dollars and it would be presumptuous at best for a review such as this to recommend one approach over the other. It is fair to comment, though, that the area of inherent ignorance is very large and that it is around the perimeter that the battles are necessarily fought. The testing tradeoffs of what kind of information for how much time and money are at the center of the conflict. ##

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Serial Number 1968 -1
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Lambda equals zero--How to analyze real failure causes

AUTHOR: E. W. Kimball, Martin Company, Orlando, Florida

SOURCE: Evaluation Engineering, vol. 4, January/February, 1965, pp. 6,20

PURPOSE: To show how the reliability effort should be reoriented.

ABSTRACT: On very high-reliability projects, ordinary acceptance tests do not suffice, rather, 100% inspection of all important characteristics must be used. It may be feasible, rather than assigning a mean life to a population, to classify the parts as defective or good. The good parts may all be expected to long outlast the need for the equipment in which they are used. Parts may be ranked in several ways; a useful one is

$$\frac{\text{fraction of that part which fail}}{\text{fraction of total parts that fail}}.$$

The following steps have been found useful in reducing electronic equipment malfunctions. If high reliability is required, failure to incorporate properly any one step can be enough to prevent the goal from being realized.

1. Worst case analysis of schematics and determination of derating and safety factor adequacy.
2. Environmental test of breadboards and prototypes prior to design release.
3. Early evaluation of tolerance buildups and transients.
4. Improve vendor effectiveness in eliminating defective sealed units prior to shipment.
5. One hundred percent inspection and test of all parts.
6. One hundred percent functional test of all characteristics after each level of assembly.
7. A "Zero Defects" program.
8. A realistic environmental test program on released design.
9. Exhaustive laboratory analysis of <u>all</u> failures.
10. A mandatory system for obtaining corrective action.

(Author in part)

REVIEW: While some of the points in the article are still the subject of some controversy, the article does present an important and valuable viewpoint. The problem of how to classify parts with regard to their importance to reliability does not seem to have been satisfactorily solved. The concept of criticality may be useful here, especially in systems with some redundancy. Another viewpoint, partially considered in the paper covered by Abstract and Review Serial Number 1910 is to rank the parts by (decrease in failure probability)/(cost of improving the part). In general, each project engineer will have to develop his own system on the

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RELIABILITY ABSTRACTS
AND TECHNICAL REVIEWS

basis of what is most important in his project. The big step is to make such a classification with full knowledge of the many possible choices.

The classification of parts into good/bad is subject to the objection that some parts are more bad than others. If a classification can be found where the parts tend to separate into two groups according to estimated life and if the members of one group are likely for the most part to fail during the equipment life and those in the other are likely not to fail, then such a classification is most worthwhile. Many parts problems (and equipment problems) are due to 'foolish failures' and can be eliminated by a simple good/bad inspection. No one scheme is going to solve the quality problems, but all should be widely discussed and available for use by the responsible engineers. ##

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Serial Number 1969
ASQC Codes 720;833;844

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

TITLE: Resistor noise screening--The do's and dont's for EE's

AUTHOR: J. G. Curtis, Senior Applications Engineer, Electronic Products Division, Corning Glass Works, Raleigh, North Carolina

SOURCE: Evaluation Engineering, vol. 4, January/February, 1965, pp. 8, 10, 12

PURPOSE: To clarify the principles of noise screening.

ABSTRACT: If a group of units (say, resistors) are intended to be quite alike in construction and performance and if a few have a noise index quite large compared to the rest of the group, then those few are quite suspect as being different in important ways. It is a problem to determine the accept/reject levels because the test is not perfect. Corning engineers noted that one noise sorting point which could be easily defined was this: That noise level quieter than that in which a maverick resistor had not been observed in any test programs. A resistor in an area that's noiser than this level should be regarded as a possible performance maverick because of its noisiness, even though it might be the only maverick in perhaps thousands of noisy resistors. Corroborating tests were temperature coefficient and life tests, since it was felt that these were most sensitive to the anticipated anomalies of film composition, film geometry, substrate and termination. The sort point, so defined, was judged sufficiently sound to serve as the basis for Corning's high reliability noise sorting program. Time has shown that sorting levels chosen by Corning lie close to perfection.

The basic rules for noise specifications are

1. Do not allow specification of a noise sort level which is not substantiated by noise vs performance data.
2. Do not apply noise sort levels for one product to another product dissimilar in materials, construction or size.
3. Because of the large numbers of resistors which must be tested to establish proper screening levels, consider the use of component suppliers' test data rather than in-house tests.

(Author in part)

REVIEW: This author has written several other papers on the same subject (see Abstracts and Reviews Serial Numbers 263, 475, and 1371). This is a summary paper which describes the test philosophy rather than its mechanics. It is apparently a useful screening test when properly used. (The Corning accept/reject point is not defined sufficiently well here to enable one to know where to put it, given the data. The author can undoubtedly supply further information.) ##

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Serial Number 1970
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability specification task requirements--methods for accomplishment

AUTHOR: H. F. Eppenstein, The Boeing Company, Aero-Space Division

SOURCE: Evaluation Engineering, vol. 4, January/February, 1965, pp. 18, 20

PURPOSE: To describe a study which determined a cross-referenced task listing of reliability specifications and standards.

ABSTRACT: A cross-referenced list of tasks has been derived from current DoD and NASA reliability specifications and standards. The 20 most general specifications and standards were chosen for detailed study. Information developed for each specification and standard includes task identification, capability to comply, costs, scheduling, implementing group, and task purpose. This information is valuable for early program planning and negotiation, and also for informing management on the company's reliability capability. The logical extension of this study is to include task requirements for maintainability, safety, technical data, etc.

REVIEW: This is a short article which briefly tells of the development of a cross-reference for tasks in selected reliability specifications and standards. The article is essentially an expanded abstract. Existence of a cross reference should provide benefits as cited in the above ABSTRACT. Anyone contemplating a similar study should be aware that DoD is currently consolidating some of the many reliability documents which were issued by various agencies within DoD. ##

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Serial Number 1971
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Analysis guidelines for failure modes, effects and criticality

AUTHOR: W. Keith Rapp, Reliability Engineer, Honeywell Aeronautical Division, Minneapolis, Minnesota

SOURCE: Evaluation Engineering, vol. 4, January/February, 1965, pp. 22, 24

PURPOSE: To establish a recommended guideline for analysis of failure modes and effects.

ABSTRACT: A failure mode, effects and criticality analysis is especially important in redundant systems where monitors are involved. The analysis must be a cooperative effort among the systems engineer, the designer and the reliability engineer--performed during system development to determine:

1. Critical failure modes.
2. Measures needed (redesign, isolation, redundancy, etc.) to eliminate and/or reduce failure effects.
3. Reliability block diagram configuration including necessary redundancy.

The analysis is conducted on both the system level and the subassembly, or black box, level. The analysis conducted at the system level is general and will only indicate the particular problems that must be eliminated to achieve an effective system design and to meet system reliability and fail-safe requirements. Analysis performed at the subassembly or part level requires complete part information if an adequate job is to be done. The same guidelines for system analysis are used at the subassembly level; however, the list has been expanded to provide better definition.

The complete analysis must be documented and a formal report issued. The type of report required will depend upon contractual requirements. (Author in part)

REVIEW: This is a good checklist for designers and reviewers. Each of the topics is covered only in generalities in a paper with the purpose of this one. Naturally, detailed treatments are possible for each point. Others will undoubtedly find a few points missing, but if all designers did the amount of work outlined in this paper a lot of equipment would be better. ##

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Serial Number 1972
ASQC Codes 715;782;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure modes for potentiometers under radiation environments

AUTHOR: W. L. Wagner, Manager, Application Engineering, Trimpot Division, Bourns, Inc.

SOURCE: Evaluation Engineering, vol. 4, January/February, 1965, pp. 28-29

PURPOSE: To present the effects of radiation on potentiometers.

ABSTRACT: Physical effects of radiation take the form of dimensional changes, mechanical strength changes or heating. Any of these may cause potentiometer failure depending on the application of the potentiometer in the system. Dimensional changes vary considerably depending on the type of material used in the potentiometer. Metals generally are not affected dimensionally. Ceramics usually swell slightly while plastics may experience more severe changes in their structural shape. In general, degradation in mechanical strength is not a severe cause of potentiometer failure under radiation environment. The results of heating, are no more severe than heating from other sources, such as load or high temperature environment.

The second major category of potentiometer failure resulting from radiation is electrical. Electrical malfunction from this environment generally originates from changes in the chemical structure of the material. The electrical changes that result from radiation on metals and ceramics is relatively insignificant. There might be a slight decrease in insulation properties of ceramics and an immeasurable resistance change in metals. In plastics, on the other hand, significant electrical changes do occur. Such things as breakdown of insulation between turns of wire in wirewound potentiometers and reduction of insulation resistance have been known to occur. These changes are generally gradual and require fairly high levels of radiation. (Author in part)

REVIEW: This is a very short general article, although there probably is not much known on the specific subject of radiation effects for potentiometers. Many of the effects can be estimated from known properties of the materials. ##

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Serial Number 1973
ASQC Codes 770;815;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Conquering the high cost of high reliability

AUTHOR: Tom Hinkelman, Director of Planning, Motorola Semiconductor Products Division

SOURCE: Evaluation Engineering, vol. 4, January/February, 1965, pp. 34-35

PURPOSE: To describe the Motorola Meg-A-Life II program.

ABSTRACT: Many high-reliability specifications have requirements in common. Three levels of test and proof have been arranged to include as many of these as feasible. Each line is treated as a unit through level 1, even before classifying into type numbers. Level 1 includes 100% "reliability processing" such as shock, high temperature, and reverse bias. The test conditions are chosen to accentuate known failure modes. Verification life tests are run to be sure of process stability. Level 2 includes burn-in and other screening tests, but with proof on the product line in general rather than on the specific lot shipped. Level 3 provides life test proof on the specific lot.

REVIEW: This is a very brief description of the program and anyone seriously interested should get information directly from the company on a formal basis. This paper is a good introduction to this program and does describe a reasonable approach to bringing order to the reliability specification chaos that exists in some areas. Costs, consideration of which is implied by the title, are not explicitly mentioned. ##

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Serial Number 1974
ASQC Codes 760;824

R E L I A B I L I T Y A B S T R A C T S A N D T E C H N I C A L R E V I E W S

TITLE: Reliability using the binomial expansion (reliability mathematics corner)

AUTHOR: Frederic S. Bernstein, Acting Chief, Artillery Branch, Ammunition Reliability Division, Picatinny Arsenal, Dover, New Jersey

SOURCE: Evaluation Engineering, vol. 4, January/February, 1965, pp. 42-43

PURPOSE: To show that confidence limits on reliability can be obtained from an operating characteristic (OC) curve.

ABSTRACT: In the binomial situation, items are classed as good or bad on the basis of some property. In sampling inspection, material is either accepted or rejected on the basis of a sampling plan. Every sampling plan has associated with it an OC curve, which is a graphic representation of the probability of acceptance of material at various levels of fraction defective. This paper shows how confidence limits on reliability can be obtained from an OC curve for a sampling plan for which the acceptance number is the number of failures observed in the sample. Illustrations are given.

REVIEW: This paper presents a non-parametric graphical procedure for obtaining confidence interval estimates on reliability. However, the clarity of the presentation leaves something to be desired. In particular, the following statement: "Conversely, we can be 5% confident that accepted material is at most 1% defective since material of poorer quality also has some chance of acceptance" should have been modified prior to publication. It should have been made clear that the OC curve must be based on the number of items in the sample and that the acceptance number must be taken as the number of failures in the sample. Apart from this there are two additional problems: (a) the author refers to 1% defective in the text, but the corresponding point on the OC curve is labelled 0.1, or 10%, and (b) the confidence limits in Figure 2 should be along the abscissa.

The author's claim for relative simplicity in the method can also be challenged. In preference to sketching an OC curve, one may use the following result which is given in [1]: If n items are tested and r failures are observed, we can assert with $100(1-\alpha)\%$ confidence that the reliability is $\geq$ b, where

$$b = \{ 1 + [(r + 1)/(n - r)] F_{\alpha} (2r + 2, 2n - 2r) \}^{-1},$$

and $F_{\alpha} (2r + 2, 2n - 2r)$ is the upper α percentage point of the F distribution with $2r + 2$ and $2n - 2r$ degrees of freedom.

REFERENCE: [1] Estimation from life test data, by Benjamin Epstein, Technometrics, vol. 2, pp. 447-454, November, 1960 ##

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Serial Number 1975
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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Redundancy and trichotomous systems

AUTHOR: John G. Rau, Systems Division, Autonetics, North American Aviation, Inc., 3370 Miraloma Avenue, Anaheim, California 92803

SOURCE: Journal of the Society for Industrial and Applied Mathematics, vol. 12, pp. 827-837, December, 1964

PURPOSE: To formally define trichotomous systems, discuss a few of their basic properties, and show how to obtain systems of high reliability.

ABSTRACT: This paper considers the problem of obtaining maximum reliability by increasing redundancy for multi-component systems in which the components are capable of three possible states of behavior. Special attention is given to majority decision schemes ("k out of n" systems). An expression is derived which gives the value of k for maximum system reliability given n and the state probabilities of the components. Consideration is also given to simple series-parallel and parallel-series systems.

REVIEW: Apart from a general discussion and illustration of the behavior of trichotomous systems, this paper consists of the mathematical development of certain theorems pertaining to such systems, given stated assumptions. As such, the paper will be of more interest to the theorist than to the design engineer. However, results of this kind form part of the broad spectrum of theory underlying the design of reliable systems.

The author, in a private communication, has indicated three reports [1,2,3] which contain more detail on trichotomous systems and their reliability. The first deals with the construction of a reliability function and an investigation of its properties for systems of identical independent components, each of which can perform in three distinct ways. The second and third contain more elementary results on trichotomous systems. Interested readers may request copies of these reports from the author.

REFERENCES:

[1] Trichotomous systems and their reliability, by J. G. Rau, Navweps Report 7234, 1 April, 1963, Naval Ordnance Laboratory Corona, Corona, California

[2] The reliability of series-parallel multichannel fuze systems, by J. G. Rau, Technical Memorandum 52-61, March, 1963, Naval Ordnance Laboratory Corona, Corona, California

[3] Reliability determination for general trichotomous systems, by John G. Rau, Technical Memorandum 52-68, November, 1962, Naval Ordnance Laboratory Corona, Corona, California ##

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Serial Number 1976
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The effect of new material and processing developments on ball bearing fatigue life

AUTHORS: C. E. Norton and P. J. Baker, New Departure Division, General Motors Corporation

SOURCE: 10 pp., presented at the Automotive Engineering Congress, Detroit, Michigan, January 13-17, 1964, Society of Automotive Engineers paper 779B

PURPOSE: To explain the material and processing innovations which have improved the fatigue life of the NDur lines of ball bearings.

ABSTRACT: This paper explains the material and processing developments which account for the fatigue life advantages of the NDur-300 and NDur-600 lines of ball bearings recently announced by New Departure.

The steel is made by vacuum-processing of air-melted steel. This is less expensive than other methods of vacuum-treating steel and is about as effective. During the forming of the races, favorable compressive stresses are built into the contact surfaces. Bearings are usually rated by the B-10 life (90% of the bearings will survive), and these new bearings have 3 to 6 times the B-10 life of previous bearings. A Weibull distribution is usually assumed although the new bearings depart from this distribution, favorably, at the higher percent of survival. Naturally, these bearings can be used for longer life or higher loads, or smaller bearings can be used for the same life or load.

REVIEW: This is a technical promotional paper to show the reasons for the higher claimed life of the bearings. Designers are always interested in a better "stronger" product. Just how the rest of the bearing industry has responded is not mentioned. ##

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Serial Number 1977
ASQC Codes 836;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability design prediction studies with reference to jet propulsion

AUTHOR: Gerhard Reethof, Large Jet Engine Department, General Electric Company

SOURCE: 7 pp., presented at the Automotive Engineering Congress, Detroit, Michigan, January 13-17, 1964, Society of Automotive Engineers paper 820B

PURPOSE: To discuss the analysis of designs for high-reliability jet engines.

ABSTRACT: The reliability design review as a highly disciplined, organized approach to failure mode/failure consequence studies is reappraised in light of jet engine design and development experience. Reliability design prediction techniques based on two approaches are described: (1) The failure rate estimate for controls and accessory parts based on historical data with similar devices under similar conditions or modified from the reference value by suitable modifier, and (2) The stress-strength probability density interference approach for engine structural parts.

Perhaps the greatest value of the reliability design prediction study rests in the fact that the design engineer for the components and the systems is forced to consider quantitatively the probabilistic aspects of the design with a level of rigor and discipline which had not been the practice of the past. Process reliability, inherent materials variations, operational modes, maintenance considerations, in addition to the tolerance definitions, normal and abnormal load situations must be carefully considered. Limitations of the approaches are highlighted, the benefits are discussed as these techniques assist the design engineer toward achieving higher levels of reliability earlier in programs. (Author in part)

REVIEW: The first part of the paper, concerned with reliability growth, is difficult to follow because some of the concepts are poorly explained. The emphasis on design analysis and review is very good. The following comment is most appropriate: "As a rule, the all-important subnominal tail ends have to be extrapolated because of the limited data available. The stress probability density curve is structured from combinations of test data and estimates of potential extreme conditions. The calculations are demanding and require a significant amount of judgments." (It is marred somewhat by a later calculation of probability for the Normal distribution out at 7σ. Use of 7σ safety margins is quite appropriate; calculating a probability from a model for that 7σ is not--unless data were gathered in that region.) ##

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Serial Number 1978
ASQC Codes 775;833;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Infrared techniques enhance electronic reliability

AUTHOR: Riccardo Vanzetti, Equipment Division, Raytheon Company, Norwood, Massachusetts

SOURCE: solid/state/design, vol. 4, August, 1963, pp. 29-37

This paper was covered by Abstract and Review Serial Number 993.
##

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Serial Number 1979
ASQC Codes 775;823;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The effect of decreasing failure rate in life testing of semiconductor devices

AUTHORS: Lawrence F. Jones and Edward B. Fowlkes, II, Semiconductor Division, Westinghouse Electric Corporation, Youngwood, Pennsylvania

SOURCE: solid/state/design, vol. 5, February, 1964, pp. 19-23

PURPOSE: To discuss the ramifications of the decreasing failure rate of transistors with respect to life testing plans.

ABSTRACT: There exists sufficient evidence today that the failure rate of semiconductor devices is generally a decreasing rate rather than a constant rate. The effect of this situation on life testing programs has started to be felt and will be greater as better procedures to verify and use decreasing failure rates are developed.

Two basic advantages to be gained with a decreasing failure rate model are the reduction in life test unit hours required to demonstrate reliability goals and the applicability of burn-in to improve reliability levels.

Two disadvantages over the constant failure rate model are the loss in flexibility of tradeoff of units with testing time to achieve specified unit hour requirements and the diminishing returns on obtaining failures as test time is increased. The latter problem increases the need for estimating reliability levels through the use of accelerated testing.

Although life test sampling plans have been developed for the decreasing failure rate model, there has as yet not been developed a practical sampling procedure that includes verification of failure rate patterns for specific devices and resulting sampling plans. This will have to be done before the present life test sampling plans for semiconductor devices are superseded.

The use of burn-in for semiconductor devices is gaining rapidly. The use of accelerated testing is increasing, particularly an approach known as step-stress testing. (Authors)

REVIEW: This is a very reasonable presentation of the material. It should be of benefit to those who wish to learn about the subject, but who wish to avoid a lot of mathematics. A previous paper by the first author dealing with some of the same material was covered by Abstract and Review Serial Number 1099. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Evaluation of passivated integrated circuits using the scanning electron microscope

AUTHORS: T. E. Everhart, Department of Electrical Engineering, University of California, Berkeley 4, California, O. C. Wells, CBS Laboratories, Stamford, Connecticut and R. K. Matta, Research Laboratories, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania

SOURCE: Journal of the Electrochemical Society, vol. 111, pp. 929-936, August, 1964

PURPOSE: To illustrate the capability of the scanning electron microscope as a tool for assessing the quality of silicon integrated circuits.

ABSTRACT: By examining passivated silicon integrated circuits in the scanning electron microscope, the surface contours of p-n junctions have been mapped, potential drops across integrated resistors have been observed, and physical characteristics of the oxide surface, evaporated leads, and bonded gold wires have been determined. Typical faults discovered by this method of testing include poor registration, improperly masked diffusions, harmful and nonharmful surface scratches, poor evaporated interconnections, and defective passivation oxide layers. Most junctions in a 40 mil square integrated circuit can be delineated with 1μ resolution in approximately 1 min by this technique.

The scanning electron microscope is useful in two roles: (1) that of a diagnostic tool in determining the source of failure in units not meeting design specifications; (2) that of a quality control inspection station in the production of integrated circuits. For the latter role the maximum information is obtained from micrographs superimposing the secondary electron emission pattern upon that due to junction photovoltage.

Under prolonged exposure, surface contamination--most likely amorphous carbon resulting from the bombardment of adsorbed hydrocarbon molecules in the vacuum system--reduces the secondary emission coefficient and increases the reverse current of p-n junctions that have been scanned. These undesirable effects can probably be reduced or eliminated by surrounding the specimen with a cooled surface or admitting certain gases into the vacuum chamber. (Authors in part)

REVIEW: This paper is the first in the open professional literature describing the potential of the scanning electron microscope as a tool for improving silicon planar device performance and reliability. However, previously released publicity notes (such as the one covered by Abstract and Review Serial Number 1310) have been well circulated so that the impact of the paper is perhaps

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

less sensational now than it might have been had such publicity not preceded it. Nevertheless the secondary electron micrographs, of which there are many in this paper, are as striking as ever. Some of the accompanying discussion is unnecessarily difficult to follow due to the small size of the reproduced micrographs and one label and one caption seem to contain errors--in Fig. 4(c) the collector symbol C seems to be misplaced; the caption of Fig. 9(a) probably should read $V_{2,3,5,8} = 4v$.

The question of how nondestructive the scanning electron beam is (see Abstract and Review Serial Number 1342) is not answered other than to note that "the complete range of effects of the electron bombardment on the oxide-silicon system are not at present fully understood, and it may prove that these have a harmful effect on passivated transistors."

In a private communication the first author has stated that the collector symbol C in Fig. 4(c) is not misplaced, but that the caption of Fig. 9(a) should read as suggested above. ##

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Serial Number 1981 -1
ASQC Codes 815;816

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability '64

SUBTITLES AND AUTHORS: Point nine, nine, nine, nine..., by E. L. Eagle, Lockheed California Company, Burbank, California and F. A. Thompson, Martin Company, Denver, Colorado

Delegated quality control puts supplier on the spot, (no author listed)

Reliability activity checklist, by R. E. Shafer, Reliability Management Consultant, 14037 Oxnard Street, Van Nuys, California

The lifetime semiconductor guarantee--revolution or revelation? by L. L. Grant, Marketing Manager, Semiconductor Division, Westinghouse Electric Corporation

SOURCE: Electronic Evaluation & Procurement, vol. 4, July, 1964, pp. 26-32

PURPOSE: To help readers keep up to date on the field of reliability.

ABSTRACT: Documented failure rates are expensive, may be misleading, and perhaps are not necessary for your product. The supplier should have an effective reliability program, however. Industrial customers want parts reliability without having to pay much extra for it.

Point nine, nine, nine, nine...
How many significant figures should be retained in the reliability number? The answer depends on how accurately one needs to know the failure rate. If reliability is converted to failure rate, then the rounding off becomes obvious.

Delegated quality control puts supplier on the spot
Not all suppliers have effective quality programs and incoming inspection usually does not check for everything that might be important. The prime contractor put his own QC men into the vendor's plant in order to upgrade the entire product cycle. Since this is rather expensive, those vendors who have met stringent requirements are allowed to police themselves and put the prime's quality stamp on the product in the vendor's plant. This has many advantages since the vendor is cut off if his quality level falls and the stamp is misapplied. Thus the marketplace pressures tend to make the vendor more severe than the prime would have been.

Reliability activity checklist
When the customer and vendor discuss reliability, a checklist is helpful. The one given in the paper is concerned with meeting the requirements of contracts, Mil Specs, and company policies. It includes reliability staff functions, reliability projects

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and programming, advanced techniques and proposals, evaluation and rating of company standards, specifications and drawings, reliability engineering and testing, and environmental factors.

The lifetime semiconductor guarantee--revolution or revelation? Westinghouse guarantees its standard (JEDEC-type) power semiconductors for the life of the products on which they are installed. This demonstrates the confidence the maker has in his power semiconductors. It allows the customer to show that he builds a reliable product, and is a valuable merchandizing tool for both of them. It is expected that other power semiconductor manufacturers will adopt this type of guarantee when they feel they can.

REVIEW: This article accomplishes its purpose of bringing more information on reliability to its readers. In general, the information is for the benefit of the non-specialist. One minor comment on the section about significant figures for reliability: In the cases where $1-R < 0.1$ the approximation that $e^{-\lambda t} \approx 1 - \lambda t$ is quite reasonable. It follows then that one is concerned with the use of significant figures in 1-R in the conventional way. (For example, if $R = 0.9946325$, $1-R = 0.0053675$ and probably two significant figures are all that are ever worth considering in 1-R.) ##

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Serial Number 1982
ASQC Code 816

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: We need to fix prices on reliability

AUTHOR: James A. Lippke, Editorial Director

SOURCE: Electronic Evaluation & Procurement, vol. 4, November, 1964, p. 66

PURPOSE: To discuss the high cost of hi-rel parts and what can be done about it.

ABSTRACT: Component suppliers and users argue about who should pay the extra costs of high-reliability parts and about the questions of standardized tests for demonstrating that reliability. It is clear that in some areas of our economy extended guarantees are not costing the customer appreciably more (some argue the customer cost is less). Perhaps the DoD, through its enormous leverage, can cause standards to be created.

REVIEW: This editorial is reasonable, although designers who do not care for and will not use standards should be criticized along with the type of contract that discourages (usually implicitly) the implementation of standards. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: 'Real cost' for DoD?

AUTHOR: (Editorial Matter)

SOURCE: Electronic Procurement, vol. 5, January, 1965, pp. 4,7

PURPOSE: To present a news item on overall cost vs. initial cost in DoD purchasing.

ABSTRACT: The Pentagon is studying a proposal that may lead to use of buying by "real cost" instead of the low bid only approach, it was reported last month.

Under "real cost," procurement would mean that the military would buy the equipment that promised to cost least over its useful life. In effect, low bids would be calculated over the life of the equipment, so the contractor that promised high-reliability parts over five years, for example, would get the nod over a bidder whose first price was lower, but would not meet the five-year reliability. In calculating total cost, the expense involved in downtime of equipment, parts inventories, and maintenance costs would be taken into consideration.

The problem would be exact computation of real cost in advance, according to Defense Department officials. They are concerned about Congressional and GAO reaction. Consideration is being given to proposals to make certain purchases with a long-term manufacturers' warranty on components, with the manufacturer responsible for all or a significant portion of maintenance costs, if any. (Entire article)

REVIEW: This approach may well be one of the most effective ways of increasing reliability. Of special importance is the idea of having manufacturers give long-term guarantees. ##

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 63A23228

Serial Number 1984
ASQC Codes 773;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Are today's avionic systems maintenance liabilities?

AUTHOR: Howard J. Avil, Jr., Aerospace Support Equipment Group, Aeronautical Division, Minneapolis Honeywell Regulator Company

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 181-186

PURPOSE: To present a reasonable viewpoint on automated checkout equipment.

ABSTRACT: A successful avionic-system maintenance-concept should include improving operational readiness, reducing aircraft maintenance down-time, requiring low skill level operators, having a high degree of accuracy, requiring no calibration (through the use of self-test), and being effectively maintainable.

The testing system must be viewed as part of the entire system which has certain objectives. Only in this way can its influence on the entire system be properly evaluated.

Automated procedures can be superior to simple manual test operations. However, the degree of automation is a prime consideration. Extensive experience in automated checkout and test systems shows that benefits of increasing the degree of control exercised by the testing apparatus and decreasing the decision-making role of the human operator reaches a point of diminishing returns. Technological and human factors have often been neglected when attempting to completely automate test and checkout procedures.

Brief outlines are given of the design concept, functional description, control section, stimuli, input and output selections, simulation of unactivated sections, analysis of results, display and readout, and self-test capacity. Several checkout devices are described in brief; they had worked very well, especially as compared to manual testing. (Author in part)

REVIEW: This paper requires some familiarity with the field of checkout equipment because it is written largely in terms of generalities. The title is somewhat misleading since the paper deals with the principles behind the development of several specific pieces of automated checkout equipment. The author's point that checkout systems can be too automated is important. A counter-argument to the apparent success of automated systems is that if the same effort had been put into the manual system, the manual system would have performed much better than it did. ##

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63A23236

Serial Number 1985
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Preferred numbers--a standardization tool

AUTHOR: R. E. Dietz, Martin Company, Orlando, Florida

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 238-242

PURPOSE: To propose a more stringent use of preferred numbers in standardizing component part values.

ABSTRACT: Preferred numbers in each decade are given in Mil Specs for 1%, 2%, 5%, 10%, 20%, and 50% tolerances and have 96, 48, 24, 12, 6, and 3 terms per decade respectively. In many situations the purchase tolerance is not the main source of variation. For example, carbon composition resistors may vary ± 20%; thus buying them to 5% decade values makes little sense. They should still be sold in 5% tolerance, but only in values corresponding to the 20% decade. An example is given in detail for the variations in carbon composition resistors. Another example applies the preferred numbers to some hydraulic hose to which they had not previously been applied. Tremendous advantages in reducing stocks can be obtained.

REVIEW: The author offers some strong arguments in favor of his position but infers that some manufacturers might have some objections. The proposed system, or, rather, the extension of the present system on the proposed basis, does have a number of advantages, if designers could be reconciled or coerced into accepting it. A key phrase in the article which serves to rebut many objections in advance is "Of course if this extreme variation cannot be tolerated the wrong component type is being considered and the designer should specify a more appropriate component part." ##

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Serial Number 1986
ASQC Code 811

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability project coordinator--an extension of the management function

AUTHOR: Duane V. Olinger, Computers and Data Systems, Autonetics, A Division of North American Aviation, Inc.

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 446-454

PURPOSE: To discuss reliability project coordination.

ABSTRACT: The reliability standards group reports to the chief engineer on the same basis as others such as the project engineer. The four main functions of this group are:

1. Failure recurrence prevention,
2. Design analysis,
3. Reliability analysis,
4. Programs and plans.

These are described in some detail. A reliability coordinator coordinates all of these activities.

REVIEW: This paper is unduly repetitious and is more a description of the activities of the reliability standards group, than those of the project coordinator. While the latter is often mentioned, his location on the organization charts is not shown at all. The article will be useful primarily to those who wish to compare their own organization with the one described in the paper. Unfortunately, it is not always possible to tell how an organization is actually run merely by reading a glowing description of it.

This paper is another added to the rapidly growing list of management-type papers which describe the nominal reliability organization of a given company.

In a private communication the author has stated that the original paper was written with the knowledge that it would be given orally; thus the paper described the main functions of the group and interjected the coordinator's efforts to maintain control equilibrium conditions; they were expanded upon at the symposium.
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Serial Number 1987
ASQC Codes 811;813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability program planning, organization and direction

AUTHOR: Harold L. Gilmore, Avco Corporation, Research and Advanced Development Division, Wilmington, Massachusetts

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 455-461

PURPOSE: To present ideas on effective and economic programs for reliability.

ABSTRACT: A discussion is given of the planning, organization and direction of an effective reliability program to meet the needs of specific customers and specific program requirements. The applicability of selected reliability program elements is evaluated on the basis of contract requirements. A unique approach to reliability program organization is presented along with recent trends in product assurance organization. Many other approaches can be presented and all can work as long as the over-all effort has the active attention and support from top management. In addition to management support, however it is important that the authority commensurate with the responsibilities associated with reliability be assigned to qualified personnel free to cross organizational lines and to provide objective, unbiased support and service.

Some of the management ideas reflected in this paper need further development. Present usage has been limited but the experience gained thus far is sufficiently favorable to warrant recommendation. (Author in part)

REVIEW: The ideas in this paper are reasonable in the context in which they are presented. Naturally, no one method is "best" even in a given set of nominal circumstances. The paper should be helpful to those who are searching for ways to organize their own programs. ##

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Serial Number 1988
ASQC Codes 815;816

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Supplier selection and control for reliability

AUTHOR: H. Donnell Hulme, Westinghouse Electric Corporation, Headquarters Manufacturing, Reliability and Quality Control

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 564-568

PURPOSE: To show some ways of selecting and controlling suppliers in order to get high reliability parts.

ABSTRACT: Procuring parts with a guaranteed reliability is a major problem to most equipment manufacturers today. Until the DARNELL recommendations are put into our military specifications and until vendors have qualified to supply to these requirements, the problem will still be with us. The Surface Division of Westinghouse is using a quality assurance specification that lists the end requirements of proof, but does not specify how to meet them. The vendor is expected to suggest methods which are compatible with his organization's procedures, yet will furnish sufficient proof of quality and reliability. Some of these tests require environmental testing in series followed by a life test. This procedure is more severe than many usual ones. Two examples: printed circuit connectors and crystal can relays are discussed. (Author in part)

REVIEW: The methods appear quite sound and reasonable for doing the best under present circumstances. This paper was published nearly two years ago and Darnell-type specifications are still not in wide use. Thus the author's hope that his methods are temporary is probably a forlorn one. The examples give some hint of the problems that can arise in dealing with vendors who do not understand enough about reliability. All in all, the paper should be most helpful to those who are faced with similar procurement problems. ##

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6

Serial Number 1989
ASQC Codes 822;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Effects of population domain parameters on statistical life tests

AUTHORS: A. O. Greer and A. A. Patterson, Armament Control Engineering, Autonetics, a Division of North American Aviation, Inc.

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August 1963 (Proceedings of the International Conference on Aerospace Support), pp. 569-574

PURPOSE: To point out that the MTBF may not be the same among nominally alike equipments and to show how this affects the sequential acceptance sampling plans.

ABSTRACT: While the exponential assumption with parameter λ (failure rate) may be adequate for each equipment, λ may be different from equipment to equipment. Suppose that λ is Normally distributed throughout the population. Then the sequential acceptance tests assuming a uniform λ will be in error. Some curves are drawn which show the magnitude of this error.

REVIEW: This is an interesting hypothesis, and appears to be well analyzed (although not all the statistics was checked). As a matter of practical application, however, it is often difficult to get enough data to make important decisions with regard to constancy over time of the failure rate. It is much more difficult to say whether the true value varies from item to item. In the author's illustration, the behavior of equipments with uniform and non-uniform constant failure rates are ostensibly shown. In point of fact, the non-uniform illustration is more likely to occur in the uniform case than is the illustration for the uniform case. The summary of the failure experience shown for each case also shows the problem in trying to decide which model is appropriate. The behavior shown is most unlikely to occur in either case; the actual behavior would appear to be much more random.

In most cases of application of the uniform constant failure rate, it is used because there are not enough data to support a more complex hypothesis or because the errors introduced by such an hypothesis are small compared to other uncertainties in the whole situation. ##

63A23271

Serial Number 1990
ASQC Code 816

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Standard hardware and corrosion: Pershing problems and action

AUTHOR: W. L. Chandler and D. E. Davis, Martin Company, Orlando, Florida

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 580-588

PURPOSE: To report on the remedies for the situation wherein incoming hardware was not plated to specifications.

ABSTRACT: During the Pershing reliability testing program, corrosion was encountered on standard mounting hardware. Investigation revealed an extremely low level of compliance of incoming hardware to the plating thickness requirements of military and Martin specifications.

Most proposed solutions would have required extensive documentation changes or additional facilities. None of the approaches directly affected the actual cause of the problem: standard mounting hardware vendors supplying material which does not meet purchase requirements.

The following approach to the problem has therefore been initiated: (1) A general purchase description for sampling, inspection and test procedures for all standard mounting hardware has been prepared; (2) Samples of hardware from a cross-section of vendors have been ordered under this purchase description; and (3) Hardware received under this program will be inspected for compliance with the drawing requirements and the special purchase description. Availability of hardware and cost increases will be analyzed. (Authors)

REVIEW: The situation described here must have moved the authors to much more emotional feelings than they felt able to express on paper. As Admiral Rickover has pointed out (see, for example, Abstract and Review Serial Number 694) the main problems are with standard commercial items and the trouble is that the manufacturer just does not really seem to care whether or not the items meet specifications. The remedies for the situation which are proposed are about as effective as they can realistically be and still keep hardware moving. ##

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63A23272

Serial Number 1991
ASQC Codes 775;833;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Infrared: a new approach for higher reliability

AUTHOR: Riccardo Vanzetti, Raytheon Company, Equipment Division, 1415 Boston-Providence Turnpike, Norwood, Massachusetts

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 589-593

PURPOSE: To present some of the applications of infrared measuring to electronic reliability.

ABSTRACT: The radiation useful in the evaluation of reliability is in the wavelength range of 1-10μ. The measuring equipment must have high sensitivity and very fine thermal and area resolution to pick up the radiation emitted by the energized electronic components. The purpose of the research work done so far is to prove that infrared techniques can be successfully used (1) to improve the design of electronic parts and equipment; (2) to reduce the number of failures through improved inspection, test and troubleshooting techniques; and (3) to improve maintenance techniques so that it will be possible to make timely identification of component parts which would cause premature failures.

REVIEW: This is a good qualitative introduction to the uses of infrared in electronic reliability. It will be helpful in finding out what kinds of things can be done, rather than how to do them. Other papers on this subject have been covered by Abstracts and Reviews Serial Numbers 626 and 993. See also Abstract and Review Serial Number 1978. This topic is a vital one for the future of high electronic reliability. ##

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63A23286

Serial Number 1992
ASQC Codes 824;838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Analytical vs. Monte Carlo methods of calculating reliability

AUTHOR: Jaan Kruus, Coordinated Science Laboratory, University of Illinois

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 730-734

PURPOSE: To derive general differential equations for the reliability of redundant systems and to point out that they can be solved in specific cases by Monte Carlo techniques.

ABSTRACT: Differential equations are derived to obtain analytically the reliability and mean life of a simple system with redundancy and replacement. They are solved for a simple case. The reliability and mean life of the system in more complex cases is obtained using a Monte-Carlo method. An excellent agreement between the two methods is obtained in the simple case. Increases by a factor of five in system mean life over the mean life of a single machine are obtainable using a simple replacement policy. (Author)

REVIEW: This is not a tutorial paper--there is no demonstration of the Monte Carlo method, nor is the derivation of the reliability equations done in detail (the mathematics was not completely checked). The equations are so general as to be of little use except to theoreticians, to whom the Monte Carlo procedures are probably well known. All in all, it is difficult to conceive of the group to whom this paper makes a good contribution, although the material itself is quite in order.

The author, in a private communication, has supplied the following erratum to the paper. "Equation (6) should read

$$Q_n(t)\, P_{S,n}(t) = P_{f,n}(t)\, \epsilon^{-\lambda t} + \int_o^t n\lambda P_{S,n}(T)\, Q_n(T) P_{c,n}(t-T) P_{f,n+1}(t-T)\, dt.$$

Corresponding corrections should be made to equations (9) and (12)." ##

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63A 23287

Serial Number 1993
ASQC Code 830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Achieving higher reliability through self-repair

AUTHOR: Richard R. Landers, Chief, TAPCO Reliability Office, Thompson Ramo Wooldridge Inc., Cleveland, Ohio

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 735-746

PURPOSE: To examine and discuss considerations of self-repairing products.

ABSTRACT: Self-repair systems are classified as shown in the chart below:

closed systems			open systems	
basic	intermediate			advanced
fixed redundant time elapsed redundant	sense and switch redundant	random redundant	self-maintaining	self sustaining self-organizing

Open systems are those which customarily are "nourished" from the outside as part of the usual routine. Man is considered to be in the self-sustaining group. These groups are described and then analyzed insofar as feasible. When making a search of current effort in physical self-repair (as opposed to mathematical investigation), it becomes quickly apparent that we are taking only the first step of a long journey. For all the talk about self-repair, practically nothing has been done to reduce to practice the many concepts recently formulated. Indications are that, while self-repair may be easy to visualize, it is not easy to achieve. Perhaps the difficulty stems from the fact that true self-repair borders on self-reproduction. (Author in part)

REVIEW: This paper attempts to organize the subject and to point out paths for productive research. Some of the comments, concepts, and analogies seem a little "far out" but that is to be expected in a field such as this. Much work has been done for computers in diagnostic routines and routing the work through properly functioning subsystems. One conceptual difficulty with many of the proposed systems is that they split the equipment into two groups of parts: those not expected to fail at all, and those that need replacement. Naturally, a critical phase of the analysis is proper placement of parts into the two groups. There is a tendency to feel that mechanical parts are long-lived and electronic ones not. See also Abstract and Review Serial Number 348 which covers a paper by this author on the same subject. ##

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63A-23289

Serial Number 1994
ASQC Codes 821;850;853

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A method of reliability estimates and demonstration data presentation

AUTHOR: Harold L. Gilmore, Avco Corporation, Research and Advanced Development Division, Wilmington, Massachusetts

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 753-758 (also Industrial Quality Control, vol. 21, pp. 505-508, April, 1965)

PURPOSE: To show how all tests during the product cycle can be used for reliability estimation.

ABSTRACT: A discussion of a method of reliability prediction, particularly useful when confronted by space applications and other cycle-significant systems, is presented. Examples of data presentation and prediction calculations are given. The various sources of test data and their relation to the mission profile are described. Reliability demonstration testing and reporting alone will not achieve the degree of reliability required of space missions. The demonstration method outlined herein is a special application of demonstration testing and data handling and is not presented as a cure-all to improving reliability.

Periodic reliability test data and estimate reporting is a requirement of many space system programs. This reporting requirement can be complied-with in a clear concise, and integrated manner. (Author)

REVIEW: These are certainly reasonable steps. They are similar to those in the paper covered by Abstract and Review Serial Number 839. As in all tests, it is important to realize that the engineering decisions and knowledge are not to be subordinated to statistics; the author has done well in this regard. ##

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63A23304

Serial Number 1995
ASQC Codes 814;872

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: No-test, no-maintenance economics

AUTHOR: Robert L. Ferguson, Aerospace Corporation, Post Office Box 95085, Los Angeles, California

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 889-894 (also published in the U. S. Army Missile Command Value Engineering Symposium Proceedings)

PURPOSE: To analyze the test-maintenance cycle to see how effective it is in improving missile reliability.

ABSTRACT: The reasons that no-test no-maintenance may be better than having them are: (1) Some missiles are degraded during the cycle, (2) Some good missiles are classed as bad, and (3) Some bad missiles are classed as good. If a simple model is developed using these notions it can be shown that there exists a limiting fraction of good missiles to be expected, regardless of initial quality. If the initial quality is higher than the limit-value, it is cheaper and better not to go through the test-maintenance cycle. More complex models could be developed if desired.

REVIEW: Even though the model is rather simple, it deals with a most important problem. The author's comment that the money spent on maintenance (in this model under certain conditions) might better be spent on improving the initial quality is most appropriate. This is a good and timely paper on a worthwhile subject. ##

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63A23307

Serial Number 1996
ASQC Codes 770;831;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure prediction employing continuous monitoring techniques

AUTHOR: Robert J. Allen, Systems Division, Autonetics, A Division of North American Aviation, Inc.

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 924-930

PURPOSE: To detail the advantages of continuous monitoring of system and subsystem performances.

ABSTRACT: Present day go/no-go type testing of missiles and space vehicles only verifies the condition of a particular section of a subsystem under test at the time of test. There is a need for techniques that predict at liftoff the condition of all subsystems during the mission.

Failure prediction techniques may be applied to systems that are checked at discrete points in time or monitored continuously. Continuous monitoring has several advantages. One advantage is that, for many units, failure prediction and reduced performance detection may be accomplished simultaneously with their normal use. This has particular application for long interplanetary and orbiting space flights. A second advantage is that switching transients during testing are minimized.

Considerable additional research is needed prior to the adaptation of some of the discussed techniques to specific subsystems. The extent to which the overall transfer function would change with component deterioration is a consideration prior to incorporating monitoring above the normal operating range of open loop servo systems. Another area for future study concerns how various components and combinations of components fail. Tradeoff studies of on-board versus ground-based monitoring with failure prediction are also desirable. (Author in part)

REVIEW: In principle there is little dispute about the advantages of continuous monitoring--other things being equal. The problem, of course, is that other things are not equal; there are heavy penalties in extra equipment and complexity. The engineering problem is to achieve a design which minimizes the penalties and achieves the optimum tradeoff of advantages vs. penalties. ##

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5/65

Serial Number 1997
ASQC Code 814

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Interfaces between reliability and value analysis

AUTHOR: Robert L. Bidwell, Value Analysis Administration, Martin Company

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 961-963

PURPOSE: To show how reliability and value engineering can help improve a product.

ABSTRACT: Costs are rising and one way to reduce them and improve quality at the same time is to use value and reliability engineering. Standardizing on fewer sizes and types of parts can yield vast cost benefits without sacrificing quality. In fact, incoming quality can then be given closer scrutiny for the same effort. A few examples are given.

REVIEW: All the facets of engineering such as reliability, value and quality when carried to the "total" limit (e.g. total quality control) turn into just plain good total engineering. Thus it is not surprising that value and reliability engineering, where properly applied by intelligent people, have the same goals. The main emphasis in this paper is on the benefits of standardizing on a smaller number of sizes of different items--a well made and vital point, notwithstanding the vehement objections of many designers. The article on preferred numbers covered by Abstract and Review Serial Number 1985 discusses this aspect of standardization in more detail. ##

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Serial Number 1998
ASQC Codes 832;864

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Design of forms for system failure reporting

AUTHORS: H. E. Thomas, Supervisory Engineer, Federal Electric Corporation, Paramus, New Jersey and D. A. Fisher, Electronic Engineer, FAA National Aviation Facilities Experimental Center, Atlantic City, New Jersey

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 964-968

PURPOSE: To describe a failure reporting system designed for modern use.

ABSTRACT: A reporting form has been designed for use by technicians who are in a hurry to repair their transistorized modular equipment and who have neither the time nor the inclination for filling out complex forms. It has ten blocks for checking off and no complex coding. The card and its description are given.

REVIEW: About all that can really be said about the system described is that it looks good and if it really works, someone deserves a medal. The situation is such that we know too little about human behavior to predict with any certainty what the actual response to a failure reporting system will be. About all we really do know is that there are generally few successes and many failures. ##

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63A23326

Serial Number 1999
ASQC Codes 832;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Basic capabilities of man and machine in respect to automated checkout

AUTHORS: Sidney I. Firstman and Nehemiah Jordan, The RAND Corporation

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 1100-1106

PURPOSE: To discuss the capabilities and limitations of automatic checkout equipment vs. service technicians.

ABSTRACT: The basic capabilities and limitations of men and machines are discussed, as they relate to automated testing of aerospace vehicles. Operators and technicians are discussed from psychological and physiological viewpoints, and present automatic checkout equipment is discussed in respect to in-system performance. Both general and specific capabilities and limitations are given. The views presented are based upon an extensive survey of field applications of automatic checkout equipment.

REVIEW: (The authors in a private communication have indicated that this paper is a condensation of parts of [1]). This is an excellent discussion and deserves to be read carefully by those with responsibilities in the field of checkout systems. The comparisons of men and machines are especially helpful. It should be emphasized that this is background information only and does not give specific design methods.

REFERENCE: [1] "Operational and human factors in planning automated man-machine checkout systems," by Sidney I. Firstman and Nehemiah Jordan, RAND Corporation Memorandum RM-2835-PR, April 1962 ##

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63A 23339

Serial Number 2000
ASQC Codes 770;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Ablestar reliability and launch site testing

AUTHORS: I. Doshay and J. A. Tusa, Space-General Corporation, El Monte, California

SOURCE: IEEE Transactions on Aerospace, vol. AS-1, August, 1963 (Proceedings of the International Conference on Aerospace Support), pp. 1227-1235

PURPOSE: To determine the deleterious effects of testing the Ablestar stage vehicle at the factory, launch site and launch pad.

ABSTRACT: A study was made to determine the influence of tests made at the factory, at the launch site and on the launch pad to establish flight readiness and system reliability. Based on data from tests on the Ablestar Stage vehicle, relationships of locational failure incidence as well as functional characteristics are developed. Failure rate levels are shown to be highly dependent on the conditions or stresses at the three different locations. It is also determined that failure rates are increasing with prolonged periods of system test. Conclusions are drawn that field tests should be minimized and only performed for purposes of multi-stage operational integrity. (Authors)

REVIEW: The subject of this paper is an important one. While the recommendations seem most reasonable, they do not appear to be uniquely determined from the data given in the paper. They are supported by the evidence, however, and undoubtedly represent excellent engineering judgment on the matter. ##

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65A15308

Serial Number 2001
ASQC Codes 770;844;851

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Semiconductor network reliability assessment

AUTHORS: J. Adams and W. Workman, Quality Assurance Department, Semiconductor-Components Division, Texas Instruments Incorporated, Dallas, Texas

SOURCE: Proceedings of the IEEE, vol. 52, pp. 1624-1635, December, 1964

PURPOSE: To discuss reliability test plans and results on silicon integrated devices.

ABSTRACT: Since the life of silicon integrated devices is so long, it is hard to estimate from scratch. Many different circuits are made from the same processing masks (except for interconnections), so that experience can be directly extrapolated from one network to another for a given manufacturer. Accelerated tests with acceleration factors up to 50 or so can also be run. Field experience seems to fit in reasonably well with laboratory tests.

A failure rate of 0.02%/1000 hr = 200×10^{-9}/hr is available on present networks. Extensive failure analysis and physics-of-failure programs are used to get rid of potential failure modes even though the exact effect of each is not known.

REVIEW: The discussions of reliability numbers and acceleration factors are a quick once-over without going too deeply into the subject. The section on failure mechanisms is quite detailed and the many examples are helpful. Much engineering judgment is essential in the evaluation of reliability factors from failure correction, but it remains an essential ingredient of the process. ##

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Serial Number 2002
ASQC Codes 835;837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Thin-film integrated electronic reliability

AUTHORS: J. W. Ireland and D. L. Fresh, Bunker-Ramo Corporation, Canoga Park, California

SOURCE: Proceedings of the IEEE, vol. 52, pp. 1635-1638, December, 1964

PURPOSE: To present a current picture of the reliability of thin-film integrated circuits.

ABSTRACT: Reliability is the most important characteristic of integrated circuits. Thin-film resistors may be made from chromium, Chromel C or cermet (silicon oxide and chromium). Conductors are gold and gold-copper. Capacitors have aluminum plates and silicon monoxide dielectric. Drift data on some resistors and capacitors are given. The resistors all changed less than 0.2% in 10^4 hr under load. Capacitors remained within 2% in 10^4 hr under a dc voltage and 125°C; they resisted humidity and temperature cycling quite well. The catastrophic failure rate (no failures, 60% confidence) is 0.014%/1000 hr for resistors and 0.057%/1000 hr for capacitors.

REVIEW: This is a more restricted paper than is implied by the title. There are drift data on two kinds of evaporated resistors and one kind of capacitor. It adds little to what is available in the current literature. In the beginning, the reliability is split into three parts, but the later figures are only for catastrophic failures. (The splitting into parts must be done carefully. If OA is the event of overall success, c is the event of no catastrophic failure, d is the event of no drift failure, and f is the event of being fabricated properly, then $P\{OA\} = P\{f\}\, P\{c|f\}\, P\{d|cf\}$, not, as the paper states, $P\{OA\} = P\{f\}\, P\{c\}\, P\{d|c\}$. It is not at all likely that the events c and d are statistically independent of f.)

The statement that "The true failure rates are actually between zero and these values..." has of course a 40% chance of being in error since the original statement was made at a 60% confidence level.

No data are given on the drift and fabrication reliabilities. No environments are given for the catastrophic failure data. ##

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Serial Number 2003
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A study of purple plague and its role in integrated circuits

AUTHORS: B. Selikson, Sylvania Electric Products Inc., Woburn, Massachusetts and T. A. Longo, Transitron Electronics Corporation, Wakefield, Massachusetts

SOURCE: Proceedings of the IEEE, vol. 52, pp. 1638-1641, December, 1964

PURPOSE: To review purple plague.

ABSTRACT: Purple plague is shown to be the development of a purple intermetallic compound $AuAl_2$ when gold wires are bonded to aluminum metallization regions in silicon transistors and integrated circuits. It is further shown that the rate of formation of purple plague is increased by the presence and interaction of silicon, and that the product is harmful to the device. Part of the ternary system is investigated to elucidate the mechanism of the ternary interaction. Various metallization-wire systems which are in use or development are reviewed. The use of aluminum wire to aluminum metallization is shown to be a simple reliable method for eliminating purple plague. (Authors in part)

REVIEW: This is an extension of a paper presented at the Second Annual Symposium on the Physics of Failure in Electronics (see Abstract and Review Serial Number 1508). It is a good review of purple plague. There is one body of thought that asserts that purple plague is a problem only in accelerated tests, that in the field it rarely if ever causes failure. Other manufacturers are experimenting with refractory wire bonds. ##

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Serial Number 2004
ASQC Codes 715;782;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Radiation experiment provides new information concerning defects on silicon surfaces

AUTHORS: C. W. Bostian and E. G. Manning, Department of Electrical Engineering, North Carolina State College, Raleigh, North Carolina

SOURCE: Proceedings of the IEEE, vol. 53, pp. 305-306, March, 1965 (correspondence)

PURPOSE: To report on radiation vs defects on silicon surfaces.

ABSTRACT: Two silicon transistor types, the p-n-p planar 2N2411 and the n-p-n precision alloy 2N498, were biased in the reverse avalanche region and classified as "noisy" and "quiet" by measurement of the microplasma noise level. The transistors were irradiated and junction leakage current measured for different exposures. It was found for the p-n-p transistors that the leakage current of the noisy units increases much more rapidly with exposure than that of the quiet units. The reverse is true for the n-p-n units. It is concluded that surface defects act as acceptors regardless of doping and that these defects must actually repel positive charges from the surfaces.

REVIEW: This result is very interesting and, if substantiated further, may serve as a valuable screening test for the selection of transistors intended for application in a radiation environment. Caution must be exercised until data on more transistor types are available since the n-p-n and p-n-p types are of different structure. For example, the oxide passivation layer on the planar transistor negates direct correlation with silicon surface defects. The ions are shielded from these defects by the oxide which may be expected to have significant influence on the observed phenomenon.

The first author, in a private communication, has indicated that while the data published in this paper were for two device types of quite different construction, more data are found in [1].

REFERENCE: [1] C. W. Bostian and E. G. Manning, The selection of transistors for use in ionizing radiation fields, IEEE Transactions on Nuclear Science, vol. NS-12, pp. 437-443, February, 1965 ##

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Serial Number 2005
ASQC Codes 300;810

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

TITLE: Guaranteed reliability--Part III

AUTHOR: D. C. Minton, Jr., Battelle Memorial Institute, Columbus, Ohio

SOURCE: Industrial Quality Control, vol. 21, pp. 536-537, April, 1965

PURPOSE: To discuss some of the key problems associated with guaranteed reliability.

ABSTRACT: Guaranteed reliability has value in improving evaluation techniques, and in assuring that reliability consistent with the state of the art is actually achieved on standard, simple, high-production parts. Past experience and data should be used as a guide in achieving part and system reliability. But significant improvements in the reliability of parts and systems must be sought in a continued program of research and development to improve techniques and processes. With adequate encouragement, a consistent growth in attainable reliability and consistency of product should result. (Author in part)

REVIEW: This is the third of four talks given at the Tenth National Symposium on Reliability and Quality Control (see Abstract and Review Serial Number 1652). Unlike the other three, this one was not published in the IEEE Transactions on Reliability, vol. R-13, March, 1964. The discussion is brief and pitched at a very general level, making it more suitable for an oral presentation than for a paper in a technical journal. The ideas are sound, but hopefully they are also quite familiar to most of those concerned with management for reliability.

The author, in a private communication, has suggested the addition of the following two sentences. "It is extremely difficult to assure that guaranteed reliability has been achieved as, in many cases, the actual reliability cannot be demonstrated with adequate confidence. For limited production applications, such as space shots, the state-of-the-art of reliability is not adequate to demonstrate achievement of reliability prediction or guarantees."
##

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65 A18751

Serial Number 2006
ASQC Codes 552;817;844;
872;882

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Some useful reliability graphs for units and simple repairable systems

AUTHORS: Ronald L. Arms and Richard D. Goodfriend, System Sciences Corporation (formerly ITT Intelcom, Inc.), Falls Church, Virginia

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 408-418

PURPOSE: To present graphical information for making reliability and maintainability analyses at both unit and system levels.

ABSTRACT: The paper is divided into two sections. The first section briefly covers calculations at the unit level where it is desired to ascertain tradeoff possibilities between mean time to repair (MTR) and mean time between failure (MTBF) for a desired level of uptime or downtime ratio for a unit, and to determine unit availability when the expected number of failures in a given mission time and the expected number of maintenance actions within a given maintenance time constraint are known.

The second section covers calculations for a system of N units when M of these units are required to be operational. Some of the complexities added to such a system by its very nature include its repair characteristics, the modes of operation of its reserve units, and its maintenance characteristics.

Further intricacies are added by consideration of possible figures-of-merit to be calculated: reliability, uptime ratio, equivalent failure rate or mean time between failures. However, not all the possible combinations of these parameters have been examined. Those that are covered in this paper are uptime ratio for an on-line repairable system, both with and without scheduled maintenance, and system MTBF for a repairable system without scheduled maintenance. (Authors)

REVIEW: This paper presents graphs which enable certain calculations in reliability and maintainability to be made quickly. Design engineers in reliability and maintainability should find them useful for obtaining rough estimates of the effects of changes in design configurations. The user of the graphs in the paper should be sure that he understands the basic calculations and underlying assumptions in order to avoid misapplication. ##

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Serial Number 2007
ASQC Codes 813;815;817

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Customerizing reliability programs

AUTHORS: Carl M. Bird and Carl J. Napolitano, International Business Machines Corporation, Space Guidance Center, Owego, New York

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 419-426

PURPOSE: To discuss a quantitative approach for the optimum allocation of funds among the various activities of a reliability program.

ABSTRACT: In establishing a reliability program the planner must select those activities which assure the highest level of reliability within specified time and cost constraints. He desires to establish an optimized reliability program by trading off reliability activities against project requirements and the design approach. This is usually a qualitative tradeoff analysis which often depends highly on judgment. A quantitative value analysis approach is developed for the tradeoff analysis. The relative worth of each activity is determined by dividing the amount of reliability improvement each activity is expected to contribute by the total improvement expected. The relative value is then determined by dividing the worth factors by an associated cost for each activity. Determination of the optimum allocation of time and funds to achieve needed reliability is guided by the relative values associated with each activity. Establishment of the quantitative inputs is subjective for some inputs, particularly for relative worth, and thus caution must be exercised in utilizing the results. Application of the approach is illustrated, including some numerical values which are based on experience.

REVIEW: In this approach a planning task which has been traditionally performed in a qualitative manner is placed in a rather simplified quantitative framework, where many of the inputs are subjective. Thus the results can be misleading, and should not be accepted as absolute. The author acknowledges this point, and it is cited for emphasis. If intelligently used, this little approach should serve as a useful supplemental tool for the difficult task of reliability activity optimization. Several lists of detailed reliability activities are presented which can be useful checklists for persons performing reliability program planning. This paper is nicely illustrated, with figures presented throughout the paper as they are introduced. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Energy source requirements for reliable circuitry

AUTHOR: Walton B. Bishop, Solid State Sciences Laboratory, Air Force Cambridge Research Laboratories, Office of Aerospace Research, USAF, L. G. Hanscom Field, Bedford, Massachusetts 01731

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 427-433

PURPOSE: To speculate about small independent power supplies producing systems of higher reliability.

ABSTRACT: Very small independent sources of energy could be used quite effectively in electronic circuitry design. Redundancy techniques can be used to overcome low reliability of such sources. Their use would remove the power supply from its status as a "vital organ" in electronic equipment. The reduction in number and length of interconnections resulting from the use of small independent sources of energy offers the possibility of improved fabrication techniques for integrated circuitry. More research and development effort on small energy sources is needed. (Author)

REVIEW: This paper appears to be "thinking out loud." The problem which is considered is more narrow than it first appears to be. There is some confusion between the logic diagram and the hardware diagram. Statistical independence is implicitly assumed throughout. There is no reason why the power supplies which are logically in parallel have to be larger than the author's "small" independent ones. The problem of optimizing in the face of constraints is not handled quantitatively at all. ##

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65 A18754

Serial Number 2009
ASQC Codes 838;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The non-operating failure rate--a valuable reliability tool

AUTHOR: J. J. Buckley, Ordnance Department, General Electric Company, Pittsfield, Massachusetts

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 434-438

PURPOSE: To point out the importance of non-operating failure rate and its value in reliability calculations.

ABSTRACT: Failures are classified into three mutually exclusive groups--operating, non-operating, and turn-off/turn-on. Some equations are derived for isolating these three groups and examples are given of their use. Tabulated failure data are likely to be ambiguous at best with regard to failure during intermittent operation.

REVIEW: The major part of the paper is taken up with the examples (little of the algebra was checked). The basic premise that parts may fail even when not operating would be difficult to dispute. The contention usually arises in discussing relative failure probabilities. In some cases, of course, operation may even be favorable (e.g., the heat may keep parts drier). There is the problem of being able to detect whether a part failed while off or during turn-on since the failure is apparent only at turn-on. ##

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65A18755

Serial Number 2010
ASQC Codes 770;813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: High reliability for space launch vehicles

AUTHOR: C. C. Campbell, General Dynamics/Astronautics (now General Dynamics/Convair), Post Office Box 1128, San Diego, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 439-448

PURPOSE: To discuss the reliability program implemented at General Dynamics/Astronautics for improving and assessing equipment reliability for the space launch vehicle program.

ABSTRACT: General Dynamics/Astronautics, under contract to the United States Air Force, designed and is manufacturing Space Launch Vehicles for use in space programs such as Ranger, Mariner, Centaur, OGO, OAO, FIRE, GEMINI, and other USAF space programs. The Space Launch Vehicle is essentially an Atlas booster which has been modified to meet the peculiar requirements of each space mission.

The reliability program implemented for Space Launch Vehicle program is tailored to meet the contract requirements which provide for rewards or penalties depending on performance of General Dynamics/Astronautics in production, delivery, and flight performance. The test program is designed to satisfy requirements for inspection, qualification, evaluation, and reliability using as few test specimens as possible.

The following six different types of tests are used at General Dynamics and are briefly described in the paper: (1) Initial Acceptance Test, (2) Pre-Production Test, (3) Production Acceptance Test, (4) Periodic Revaluation Test, (5) Stress Limits Test, and (6) Extended Time Test. Procedures used in the laboratory to isolate equipment weaknesses and to obtain data for reliability assessment are described in detail. The paper also discusses the techniques used to establish realistic test conditions, the criteria used to classify failures and to evaluate test results, and summarizes the results achieved to date. (Author in part)

REVIEW: This is a good brief description of a specific reliability program. As such, it may be of interest and value to those concerned with setting up and operating similar programs. ##

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Serial Number 2011
ASQC Codes 773;780;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failures induced by environmental test equipment

AUTHORS: A. H. Samuels and M. J. Deutsch, Product Evaluation Department, Aerospace Group, Hughes Aircraft Company, El Segundo, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 449-458

PURPOSE: To discuss prevention of failures of environmental test equipment.

ABSTRACT: Emphasis on environmental testing focuses attention on effectiveness of environmental test equipment. Failure of the equipment, insufficient preventive maintenance, or errors in operation result in schedule slippage or test specimen damage. This paper presents an extension of reliability analysis techniques useful in predicting potential sources of trouble before actual failures occur. The method is called trouble effect analysis and resulted from a joint effort between the test engineer and the reliability engineer. One of the key features of trouble effect analysis is the systematic tabulation of undesirable effects. The analysis procedure consists of:

1. Forming a list of discrete items (physical or procedural) which can be identified with a properly operating test facility.
2. Specifying the possible basic modes of failure for each individual item (hardware failure modes for physical items; types of errors for procedural items).
3. Forming, where appropriate, combinations of the basic modes of failure.
4. Determining the effect of each failure mode or combination of failure modes on the test specimen and the test facility.

This method of step-by-step categorization is responsible for the major favorable features of the technique: minimizing the chances of overlooking important sources of trouble, detecting unsuspected interactions, providing a natural method for ranking the importance of potential trouble sources, and providing clues to efficient solutions to a combination of problems rather than to one problem at a time. (Authors)

REVIEW: This paper concerns the effects on the device under test and on the environmental equipment itself of some procedural error, failure in the environmental equipment, or failure of the utilities supplying it. Emphasis is placed on the effect of errors in test procedure (including calibration). The methods and formats outlined for analysis and operation seem quite reasonable. (The discussion of conditional probabilities may be somewhat misleading. The need for conditional probabilities is well put, but anyone trying to use them should get professional help since they can be tricky.) ##

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Serial Number 2012
ASQC Codes 813;836;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Assuring reliability in aerospace batteries

AUTHORS: Louis Gomberg and Helmut Thierfelder, Radio Corporation of America, Astro-Electronics Division, Princeton, New Jersey

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 459-469

PURPOSE: To describe the program which has been developed by the Astro-Electronics Division of RCA to assure the design, development and manufacture of reliable nickel cadmium batteries for spacecraft.

ABSTRACT: The nickel cadmium battery system offers one of the most reliable battery systems available for space vehicle application. Advantages include: (1) extensive life cycling, (2) good overcharge capability, and (3) long-life plate materials. Failure modes and mechanisms include internal shorts, high or variable internal resistance, capacity loss, high end-of-charge voltage, and loss of seal integrity. A failure-detection program includes: (1) detection of internal shorts by stand tests, vibration tests and capacity tests, (2) tests for high or variable internal resistance, (3) tests for high end-of-charge voltage. Incoming inspection proves to be a most useful tool for weeding out incipient cell failures. In this inspection, all cells are plotted for capacity, end-of-charge, and discharge voltage. All cells above or below $\pm$ 2 standard deviations are discarded. The vendor quality control program is important in good battery production. A review of battery design is given. A program of reliability prediction has been undertaken, but the results are somewhat controversial and are not clearly definitive. Nickel cadmium batteries can be made and tested to give a very high degree of reliability. With aerospace sealed cells, a life of ten years should be attainable.

REVIEW: This is a good outline of a design and surveillance program for high reliability nickel cadmium batteries. The work should be of interest to all involved in the manufacture or use of high reliability nickel cadmium batteries for military or aerospace application. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: RADC Reliability Central

AUTHORS: David F. Barber, Milton Haus, and John L. Fuchs, Reliability Branch, Rome Air Development Center, Griffiss Air Force Base, New York

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 470-479

PURPOSE: To discuss the concept of the RADC Reliability Central, the approach being used to implement it, and the progress achieved to date in its development.

ABSTRACT: The development and establishment of a "Reliability Central" at Rome Air Development Center is now under way. The Central will serve as the Air Force focal point for the acquisition, storage, analysis, and dissemination of reliability information. Initially, the Central's operation will be limited to electronic part types covered by Federal Stock Class 59. Eventually, the operation will encompass semiconductor integrated circuits, mechanical and electromechanical parts, equipment, subsystems, and systems.

A Central Management Office of RADC personnel has been established to implement the Central with necessary contractual support. The Central's organization will include a field team or liaison group, a parts engineering group, and a data processing and analysis group.

Prior to the establishment of a full scale Central, a test operation on transistors and diodes will be developed and implemented to demonstrate the feasibility and potential of a full scale system.

Presently, two contractual efforts are under way for the "Development of the Detailed Implementation and Operational Plan for a Reliability Central" and the "Design of a Storage and Retrieval System for the Central." These are scheduled for completion by May 1965. Prior to the end of 1964, two contractual efforts will be under way for the collection, reduction, processing, and analysis of existing part data generated under Minuteman and other Air Force programs. These will establish the data base for the Central. The development of the test operation will start in early 1965, and will be completed by mid-1966.

Following the completion of the test operation, the Central will be rapidly expanded to encompass all electronic part types by mid-1968, and semiconductor integrated circuits by mid-1969. The expansion of the Central's file to incorporate reliability information on equipment, systems, and mechanical and electromechanical

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A N D   T E C H N I C A L   R E V I E W S

parts and assemblies will be accomplished in an orderly manner thereafter. (Authors)

REVIEW: This is a quite detailed paper which accomplishes its purpose well. The Reliability Central, as a program to organize reliability information at all hardware levels, should do much for the reliability of Air Force systems. ##

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65A18758

Serial Number 2014
ASQC Codes 842;844;846

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure rate by mode of failure data

AUTHOR: George R. Herrold, The Boeing Company, Aero-Space Division, Seattle, Washington

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 480-486

PURPOSE: To describe a method of assessing the fraction of part failures due to specific modes of failure.

ABSTRACT: A format for presenting failure rate information on specific parts is described. As implied by the title, the important feature of this format is a provision for classing the failure of any part into several modes. The estimated frequency of each mode is then given. Not all the data are available that are needed; so compromises must be made in assigning the numbers. An estimated validity-index is assigned to each rating sheet which shows the ratio of facts to guesses involved in the ratings.

REVIEW: The classification of failure data into modes of failure is a good idea. The paper presents a realistic approach to the problem by trying to do the best we can with what we have. There are many advantages to having all the "worry and sweat" done by a central group so that each engineer or department need not repeat the process each time there is a need. There appears to be no classification by manufacturer which may prove to be a disadvantage. (If the failure classifications are mutually exclusive, in principle it is not possible to assign a Poisson failure rate to each. However, if the failure probabilities are small, the errors in such assignments are small.)

Regarding the absence of classification by manufacturer, the author in a private communication has commented as follows: "The identity of part manufacturers was omitted at the suggestion of our legal department although this information is available to Boeing personnel." ##

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Serial Number 2015
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability and the incentive contract

AUTHORS: S. R. Kalin and R. D. Johnson, Jr., Operations Research Incorporated, Silver Spring, Maryland

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 487-500

PURPOSE: To describe the multiple incentive contract in government procurement, to examine some current problems, and to outline efforts on establishing improved contracting methods.

ABSTRACT: There is every indication that use of incentive contracts in government R & D procurement will increase. The formula for determining the fee is contained in the contract. Inducing the contractor to additional effort can possibly be thwarted by negotiation results which may initially appear successful from the government point of view, i.e., small increase in fee for large increase in performance. Another limitation is that separate fee payments for each parameter tend to disregard the interaction between parameters, as it is usually much more difficult to simultaneously achieve multiple parameters. This typical approach virtually guarantees that improvements in both areas will not be delivered. Other problems are those associated with proof of attainment of parameters, particularly reliability, and also those which are involved in establishing the value of reliability. The basic principles are outlined for a generalized incentive model which is to meet the problems of current incentive contracting problems. These principles should lead to techniques which provide a systematic means for relating multiple incentive parameters and combinations of parameters to value and fee.

REVIEW: This paper is apparently based on interim progress of a study on reliability and incentive contracts, and additional results are forthcoming. The strong feature in this paper is recognition of the conflicting objectives and motivations of a buyer and a seller, which hints of some new approaches. Techniques are needed which result in both increased fee for the contractor and increased benefits for the government; those persons interested in reliability incentive contracting will be looking forward to further results of these efforts for development of such techniques.

The 13 figures which follow the text are not numbered, and apparently the figures in second and third places are reversed relative to their mention in the text. Also, several of the figures which are graphs apparently have lines which did not reproduce.

The papers covered by Abstracts and Reviews Serial Numbers 1835 and 1889 are also on incentive contracts. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Comparing military and commercial assurance plans

AUTHOR: Walter F. Lutzweit, Product Assurance, Lockheed Missiles & Space Company, Sunnyvale, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 501-505

PURPOSE: To compare military and commercial product assurance plans.

ABSTRACT: The principal goals of military and commercial product assurance plans are the same, but the actual programs are different. This paper presents these differences by describing military and commercial programs separately under the headings:

1. Feasibility and Planning
2. Engineering and Development
3. Building and Inspection
4. Debugging and Production
5. Maintenance and Service.

The military assurance plans are formalized and more elaborate but the risk is lower for major breakthroughs during a tight schedule. There is room for improvement in this type of assurance plan in that it should provide for more before- and after-the-sell service. Initially this would increase program costs but the increased cost would be quickly offset for future programs by a reduction in design deficiencies and by increasing the product assurance.

The industries using the commercial programs are less formal with fewer assurance check points. The risk is not excessive as long as the new device is patterned after their product mix. However, a commercial assurance plan will not produce new products acceptable to military standards at lower cost or less of a risk than government captured corporations. Furthermore, some subcontractors using their own assurance plans significantly increase the risk and the cost of military programs, over and above what it would be if the prime military-oriented industry had done all of the work, because of the retraining involved.

The commercial programs would greatly benefit from reliability testing of their products and training personnel to use prediction techniques. This would eventually reduce to a minimum engineering by trial and error. (Author in part)

REVIEW: This is a good brief discussion of the subject, which serves to highlight the main differences between military and commercial reliability/quality assurance programs. Presumably there is considerably more variety in commercial approaches than in the programs

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AND TECHNICAL REVIEWS

dealing with products for military procurement. When the general public is the customer, there is no customer-authored specification drawn up beforehand, and no in-plant surveillance by the customer to see that specifications and requirements are met. But there is customer satisfaction and customer goodwill which the producer strives to win. In many specific ways the producer of commercial items should be able to benefit by the approaches to reliability and quality assurance of the military programs.
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Serial Number 2017
ASQC Codes 431;824;837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An application of random drift to reliability analysis

AUTHOR: Kenichi Majima, Kobe Kogyo Corporation, Okubo-cho, Akashi-city, Hyogo-ken

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 506-509

PURPOSE: To present an application of the random walk probability model for diffusion processes to the degradation of transconductance of a vacuum tube.

ABSTRACT: The initial and elapsed time distributions for this application are Normal, where later distributions are such that the mean is proportional to the elapsed operating time and the standard deviation is proportional to the square root of the elapsed operating time. These relations between the initial and later distributions are the drift and diffusion coefficients. This technique has potential application for decreasing the hours required for life testing, and for reliability analysis of electronic circuits. Some features of this random-walk probability model are discussed. An experimental application of the model to a sample of vacuum tubes is briefly described, and some results are presented. Observations from the completed life test coincided fairly well with the theoretical calculations which were based on observations from the early time periods of the test.

REVIEW: This paper suggests a method for describing performance degradation with time of the characteristics of electronic parts. There have been few publications in the reliability analysis literature on explicit methods for considering drift over time, thus making the suggested method and experimental results of timely interest. The proposed model appears useful in reliability analysis if the underlying assumptions are reasonably satisfied. It would seem there should be more appropriate methods than used in the paper for estimating the drift and diffusion coefficients from test data. The features of verifying the assumptions for random-walk models and of most appropriately estimating the diffusion coefficients are not cited for analyzing the life-test observations. For example, data were apparently taken at 0, 500, 750, and 1000 hours, but only the data at 0 and 1000 hours were used to estimate the coefficients after 1000 hours had elapsed. No mention is made of why this was done. There is some understandable minor language difficulty, such as the use of chance failure instead of catastrophic failure. ##

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65 21876l

Serial Number 2018
ASQC Codes 831;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: NET-1 network analysis program

AUTHOR: Alan F. Malmberg, Los Alamos Scientific Laboratory, Los Alamos, New Mexico

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 510-517

PURPOSE: To describe the NET-1 network analysis program.

ABSTRACT: This paper describes the NET-1 digital computer program developed at the Los Alamos Scientific Laboratory. The program simulates the DC steady state and transient behavior of a large class of electrical circuits.

A circuit described to NET may include the following elements connected in any manner so long as the connections remain fixed: junction transistors and junction diodes; signal sources and fixed voltage sources; and fixed-value resistors, capacitors, inductors, and mutual inductive couplings. Special features are available to analyze circuits containing switches.

The major objective of the program has been to allow circuit designers with no computer experience to obtain satisfactory analyses on any circuit which can be built out of the allowable parts (subject to memory size restrictions). The program is completely automatic and no knowledge of computer programming or mathematical methods is required of the user.

The circuit restrictions, five basic signal source voltage waveforms, and an example of the NET-1 input and output are given. In addition, the diode and transistor models are briefly described. (Author in part)

REVIEW: This paper would be of interest to circuit designers. No knowledge of computer programming or mathematical methods is required by the user of NET-1. The program is presently limited in its application due to the number of types of diodes and transistors which are contained in the library. Furthermore, one should become familiar with the models for diodes and transistors and their possible limitations. The parameters of the models can be altered as indicated in the paper.

Future plans for altering the NET-1 program to allow component parameter variations to be included and for expanding the library are given in the paper covered by Abstract and Review Serial Number 1818. ##

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6/65 65A 18762 Serial Number 2019 -1
ASQC Codes 821;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An automatic reliability mathematical model

AUTHORS: C. W. McKnight, L. J. Modiest, and N. E. Schmidt, North American Aviation, Inc., Los Angeles Division, Los Angeles, California

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 518-532

PURPOSE: To describe a computer method of evaluating a system reliability model.

ABSTRACT: The Automatic Reliability Mathematical Model (ARMM) is a general-purpose analytic computer program that evaluates a system reliability mathematical model from a computer-oriented system description. It can be used to conduct the reliability analyses of a wide range of system configurations as well as a variety of mission profiles.

In the reliability analysis of a manned vehicle, the adoption of an alternate flight plan due to specific component failures, as well as changes in system configuration from one phase of a mission to another, can be considered. Both the probability of mission success and the probability of vehicle safety may be determined with mathematical models which are derived by a single program analysis. The evaluation of the reliability of a manned vehicle, which has abort criteria specified, requires the use of complex integrals as well as the consideration of the interrelationship of the two probabilities.

Probability theorems are applied in a sequential manner in order to determine the system reliability equation. This program-derived equation is composed of a series of component failure integrals which are evaluated by Simpson's rule of numerical integration.

This program has become a versatile probabilistic tool which can be used for a variety of system analyses. Although the program was originally designed to calculate air vehicle reliability, it is adaptable to, and has been used for, the calculation of the reliability of many other complex systems and for a number of other probabilistic system analyses, including some aspects of maintainability. (Authors in part)

REVIEW: From the information in the paper, it is difficult if not impossible to review the actual program. However, the feeling one gets from the paper is that the program most likely does its job quite well. Admittedly it is difficult to describe such a program. The paper dwells on the probability aspects considerably. The notation is very poor since exactly the same symbol is used both for the

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event and for its probability. This can and does generate some confusion. The references to Bayes' Theorem are out of place since the two formulas used are the definition of conditional probability and the generalized law of addition (sometimes referred to as the rule of elimination). The equations given on pp. 522 and 528 (bottom of second column) in the paper, and referred to as Bayes' Theorem, correspond respectively to Equations 13.1 and 13.2 on p. 122 in [1]. However, they are not Bayes' Theorem, as reference to p. 39 in [2] will verify. In fairness to the authors of the paper, this error must be attributed to the author of [1]. The events of success and failure of components are presumed to be statistically independent, regardless of all the discussion of conditional probabilities. This is very restrictive if there is more than one likely mission profile with different probabilities of failure for each. The program can handle some types of dependence, for example, mutually exclusive failure modes. It is very doubtful if it can handle the type where all the a priori probabilities are changed due to the knowledge of failure of a component.

There is some semantic difficulty regarding whether the program will create the model for the circuit as claimed in the paper. If the computer is given the "reliability diagram" (and success is defined as any path through the diagram), then it can generate the appropriate expressions since they are logically implied by the diagram. Some people prefer to call the original "reliability diagram" the model; others prefer to call the resulting equations the model. The point of view taken in this abstract and review is the former.

Basic assumption 4 is not stated properly (if it were in terms of events rather than probabilities, it would be correct).

From such a paper as this it is not possible to say how well the program works in practice, compared to other programs. It does have many desirable features such as identifying the contribution of each component to system failure and taking into account performance degradation. (The latter function is not explained too clearly and may be a rather restricted function).

REFERENCES: [1] Reliability Theory and Practice, Igor Bazovsky, Prentice-Hall, Inc., 1961

[2] The Elements of Probability Theory and Some of its Applications, Harald Cramér, John Wiley & Sons, Inc., 1955 ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Manned space stations and mission effectiveness

AUTHOR: A. H. Ramquist, Advanced Technology, Systems Reliability, The Martin Company, Denver, Colorado

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 533-541

PURPOSE: To describe some of the implementation to determine mission effectiveness and its constituent elements.

ABSTRACT: A manned space station will demand maximum attainable probability of mission success and mission availability to yield the required measure of mission effectiveness. Basic definitions, problems, and concepts that control "long duration" manned missions are discussed. Such a station must be designed to allow for failure, then repair, and system restoration; therefore, the classic definition of reliability is replaced by the "probability of mission success." Problems associated with maintainability, replacement, and availability are noted, and several types of redundancy are discussed in relationship to these requirements. Attention is directed to component/subsystem wear-out in prolonged missions and its effect of increasing the failure rate. The deleterious effect on failure rate due to maintenance actions also is noted. "Interval reliability" of subsystems critical to a mission is discussed. These many interdependent factors make the determination of mission effectiveness very complex.

Several models are presented for handling the redundancy types, to predict number of failures at a required reliability, and to account for an increasing failure rate due to "wearout." An overall technique is proposed for determining probability of mission success and mission availability. This technique basically consists of breaking mission time into several increments, each with its own failure rate which reflects cumulative operating conditions. The concern is for a practicable, straightforward solution to this complex problem. (Author in part)

REVIEW: This paper is a reasonable discussion of the definitions, concepts, and problems involved in getting a first approximation to the mission effectiveness of a manned space station. The author has made it quite clear that the approach suggested is an approximate one. As the state-of-the-art advances, and more pertinent data become available, refinements in estimation and prediction techniques will become possible. An important aspect on which data are yet to become available in reasonable quantity is the psycho-physiological or human factors element.

The author's suggestion of adding a wear-out failure rate to the

constant failure rate and using the result in an exponential distribution raises at least three questions. For example:

1. How important is it to consider wear-out at all with high-reliability equipment in the time intervals which are involved?

2. Are you really better off to use the suggested approximation than you would be if you simply neglected wear-out, at least until better data become available?

3. Given that wear-out must be considered, would it not be better to use some distribution such as the Weibull, which allows for a nonconstant (e.g., increasing) failure rate?

The reader may also wonder about the fact that no distributional properties are assumed for time-to-repair. Maybe this is because repair is envisaged as consisting mainly of exchanging modular packages. If so, it might be best to think in terms of replacements which are planned so as to avoid the wear-out period. These are among the problems which remain to be solved as more and better data become available. ##

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Serial Number 2021
ASQC Codes 813;815;850;
870;880

R E L I A B I L I T Y A B S T R A C T S
A N D T E C H N I C A L R E V I E W S

TITLE: Selling your reliability program to the Air Force Electronic Systems Division

AUTHOR: Milton V. Ratynski, Electronic Systems Division, Air Force Systems Command, L. G. Hanscom Field, Bedford, Massachusetts

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 542-556

PURPOSE: To discuss the factors which must be developed by prospective contractors to the Air Force Systems Command (AFSC) Electronic Systems Division (ESD) in order to assure responsiveness to the reliability requirements.

ABSTRACT: Technical proposals for military electronic systems, projects, and equipments are now critically reviewed by an ESD evaluation board from the design-for-reliability viewpoint. Contractor proposals must establish reliability in proper perspective to such support aspects as maintainability and logistics; ESD prefers a single combined program plan. A first prediction of reliability capability for the proposed equipment is required, including all assumptions and data sources. The technical proposal should clearly indicate the specific procedures which will assure that all designs and any subsequent changes are subjected to effective reliability design reviews. Other obligations of the prospective contractor are those for reliability demonstration, failure data collection systems, and provision of a reliability organization. The effect of reliability upon maintenance costs is explored. Basic approaches for increased reliability are discussed. Twenty specific aspects are outlined which must be developed and fully detailed in the technical proposal in order to be responsive to reliability requirements.

REVIEW: This is a wordy exhortation to prospective AFSC ESD contractors, covering what proposals "must" contain for reliability and is based on current regulations. A large amount of background material is presented, some of which is only loosely tied in with the theme of the paper. Government contractor personnel should use their good judgment and past experience in determining how strong these "musts" are. However, as any regulation is only as meaningful as the enforcement personnel make it, contractors should note that according to this paper the system and project offices are being staffed with competent, qualified professional engineers and that unbiased technical assistance outside of the AF is utilized to advise the proposal evaluation boards. The twenty-point summary of proposal "musts" is a compact checkoff list, and those contractor personnel involved in preparing AFSC ESD proposals will want to be familiar with its contents. ##

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6/65

65A18764

Serial Number 2022
ASQC Codes 440;824;837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Mathematical models for drift failure analysis

AUTHOR: Martin L. Shooman, Department of Electrical Engineering, Polytechnic Institute of Brooklyn

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 557-567

PURPOSE: To discuss several mathematical techniques which are available for the analysis of drift failures at a fixed instant of time.

ABSTRACT: The conventional deterministic techniques of drift failure analysis are "stacking-up-the-tolerance," worst case analysis, and expansion of the performance function in a Taylor series of linear terms. A probabilistic interpretation is given to the results of these worst case techniques. They are simple to apply but are rather inaccurate in many cases. The general probabilistic approach involving the change of random variables theorem is discussed; however, the resulting integral expressions are amenable to solution and interpretation only in special cases. More cases can be solved if only the moments of the performance function are desired. Results of the application of these techniques to some simple functions and commonly-used distributions are presented in several tables. The method of obtaining moments from a Taylor series expansion of the performance function is presented, including non-linear terms. This technique is considered to be adequate in most cases, and it can possibly be checked by numerical solutions from other techniques in doubtful instances. (Author in part)

REVIEW: Emphasis in this paper is on the exact analytical approach, which will usually not be applicable to actual engineering situations. Thus the main topic is the approach which is often very briefly cited and dismissed in reliability-oriented papers dealing with drift analysis. Possibly the primary value of the exact analytical approach is that it gives greater insight into the problem. The tables shown will make handy reference material. The remaining techniques dealing with worst case approaches, moments, and Taylor series expansions have received considerable attention in the reliability literature, although this paper includes two aspects which are often not treated. In the worst case technique referred to as "stacking-up-the-tolerances" the percentage tolerances on the independent variables are simply summed without regard to the form of the function relating the variables. The author notes that this is a conservative but naive approach; it does not seem to have been mentioned elsewhere in the current reliability literature. Also the inclusion of non-linear terms in the Taylor series expansion appears to be unique. ##

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65 N19765

Serial Number 2023
ASQC Codes 817;838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Optimum redundancy for a satellite power system

AUTHOR: Lee R. Webster, Republic Aviation Corporation, Farmingdale, New York

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 568-574

PURPOSE: To demonstrate the practical application of certain reliability optimization procedures which were developed previously.

ABSTRACT: Reliability optimization procedures based on improving the reliability of subsystems by means of redundancy were given in the paper covered by Abstract and Review Serial Number 1267. This work was based on that of M. Sasaki (see Abstracts and Reviews Serial Numbers 496 and 978). In this paper the procedures are applied to a system composed of 14 subsystems. Many of the intermediate calculations are shown to make the method clearer.

REVIEW: This paper accomplishes the limited purpose set forth by the author. The best methods for improving reliability depend heavily on the presumed causes of unreliability. In this case, the connections and wiring were causing the failures and so were made redundant. Extreme care must be exercised in the use of redundancy to be sure that the failures are in fact statistically independent.

See also Abstract and Review Serial Number 1910. ##

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Serial Number 2024
ASQC Codes 431;821;838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability of a redundant system with two failure modes

AUTHORS: Stuart A. Weisberg and Gerald H. Sandler, LEM Reliability Section, Grumman Aircraft Engineering Corporation, Bethpage, Long Island, New York

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 575-579

PURPOSE: To present a method of reliability analysis using a Markov process for two possible failure modes of each of two redundant elements.

ABSTRACT: The design of space systems presents many reliability problems which are generally not encountered in more conventional systems. This paper presents a method of reliability analysis used for the evaluation of a Reaction Control system of a manned space vehicle. The model developed is based on a situation where (1) the system is used in several phases of the mission, (2) the environments vary in each phase, and (3) two failure modes are considered. A Markovian model describes the system reliability behavior in terms of system states and transitions between states from phase to phase. While the model was developed for a particular application it is sufficiently general so that it can be applied in many similar situations. The mathematical techniques employed and the resulting model are general and can be used to determine the reliability of any two-fold redundant system for a multiphase mission. (Authors in part)

REVIEW: This is a rather mathematical paper and the results are probably not too easily applied by many design engineers. The statistical dependence of failures can be taken into account in this model. Not all of the mathematics was checked, but the procedure appears to be quite straightforward. ##

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65A18767

Serial Number 2025
ASQC Codes 837;844;851

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Functional reliability evaluation technique--FRET

AUTHOR: Robert L. Weiss, International Business Machines Corporation, General Products Division, Endicott, New York

SOURCE: Proceedings Eleventh National Symposium on Reliability and Quality Control, Miami Beach, Florida, January, 1965, pp. 580-586

PURPOSE: To show how a short hardware test may be used to identify reliability problems in the order of their importance.

ABSTRACT: The functional reliability evaluation technique (FRET) was developed as a result of a search for a fast reliability test to supplement or replace standard mean time-to-failure tests. It is a sequential stress technique where the stress is carefully selected and applied in a manner that permits the analysis of failure data in terms related directly to performance. The technique is applied to functional areas, a functional area being some part of a machine or system which has a single specific mission to perform. A typical mechanical function is described and used throughout the paper for purposes of illustration. The machine fails intermittently as stress levels increase and eventually is forced to fail on every operation. Interest is in the failure pattern of the machine or complete system brought about by stressing individual functional areas. Analysis of the system failure pattern results in isolating reliability problems and predicting functional failure rates. The physical FRET test is related to reliability theory, providing background information for FRET analysis of more complex machine functions. An example is given and a method of isolating and measuring reliability problems is presented. Applications are discussed and an electrical analogy is suggested.

REVIEW: This paper describes and illustrates the subject technique quite well. The author, in a private communication, has pointed out that there is a subtle difference between this technique and the usual accelerated tests. Stress is not used to attempt to accelerate wear or other deterioration processes, but rather to obtain a measure of the strength of a test vehicle, and particularly the variation of strength due to dynamics, adjustments, parts tolerances, etc. The statistical relationship of these engineering parameters to strength, and ultimately to reliability, is a unique feature of this technique. In conducting a FRET test, it is essential to establish that only one failure mode exists during the test; if more than one exists, they must be separated in the data analysis. The nature of the technique predicts from the mean and dispersion of strength the probability of each failure mode occurring at nominal stress; if a failure mode is unlikely in normal use, the technique will so indicate. ##

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Serial Number 2026
ASQC Code 824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Predicting system checkout error

AUTHOR: Warren D. Moon, Aerospace Systems Division, Radio Corporation of America

SOURCE: Electro-Technology, vol. 73, January, 1964, pp. 46-50

but see 66A19740 + 66N19842

PURPOSE: To analyze the effects of random errors on checkout decisions.

ABSTRACT: During system and component testing there may be either a failure to detect an existing defect or the false detection of a non-existent defect. This article develops methods to estimate both types of test errors. The probability equations used here may also be applied to specify the design of new test equipment. The approach described was developed in connection with work on the lunar excursion module portion of the Apollo program. The assumption is made that bias is negligible and that the distribution of measurements of a parameter is Normally distributed with mean equal to the true value. (Author in part)

REVIEW: The subject treated here is an important one, but the details of the treatment are weak. While it is stated at first that a Gaussian distribution is used, in reality, by the time the distribution itself is used in computations, some other one is employed. It is not clear which one since it is drawn as a probability density curve, but labeled as on a cumulative distribution curve. Upper and lower limits are both inserted in the "false-alarm" calculations, but inconsistently are left out for the undetected defect. Also in the false-alarm case, the answer is a function of the measurement; this was not done for the undetected defect. While the answers probably are the same in either case, classical statistics insists that the true parameter value is fixed and that confidence statements are made in assertions concerning it. Some of the system formulas assume statistical independence without so stating. There probably is little need to consider both upper and lower limits in the same analysis since it is a complicating factor and should be quite negligible in any practical case. The "linear" approximation to the Gaussian distribution is probably not necessary since the results would have been straight lines on Normal probability paper. The discussion of basic assumptions is quite good except that the author is overly optimistic in hoping for real knowledge of a distribution function out in the 10^{-6} tail region. ##

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64A16052

Serial Number 2027
ASQC Codes 821;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Simplifying system-reliability calculations

AUTHOR: John G. Lawrence, The Bendix Corporation, Eclipse-Pioneer Division

SOURCE: Electro-Technology, vol. 73, March, 1964, pp. 109-114

PURPOSE: To show how to simplify calculations of system reliability.

ABSTRACT: Reliability calculations for events which are combined into a logic diagram can be simplified by using a theorem from probability theory.

REVIEW: The mechanics intended to be described in the paper are correct, but the explanation uses terminology which is confusing at best. Some of the introductory probability rules are wrong (e.g., it is stated that if $c = \bar{d}e$, then $\bar{\bar{c}} = d\bar{e}$; a correct statement is if $c = \bar{d}e$, then $\bar{\bar{c}} = d + \bar{e}$). The statement "Mixtures of exclusive and non-exclusive events make the general rule inapplicable" is obviously wrong. The formula $P(A) = \Sigma_i P_i\ (A|X_i)\ P(X_i)$ where X_i are an exhaustive mutually exclusive set is not generally derived from Bayes' theorem as stated in the paper; rather one form of Bayes' theorem is derived using it. See, for example, p. 39 in [1]. There are several misprints which lead to confusion. The designation of some events as "independent" is misleading since all the events A, B, C, ... are presumed to be independent in the article.

In short, the proposed method of calculating the probability of system success is a most valid and useful one (where the concepts of success and failure of blocks are applicable); the explanation of that method in this paper is poor but apparently does suffice to demonstrate it.

The trick in this method is to choose the events about which the probabilities are expanded in such a way that as many as possible of the combinations will have zero probability and thus the terms involving them will drop out. The author has given several examples which illustrate this point.

REFERENCE: [1] The Elements of Probability Theory and Some of its Applications, Harald Cramér, John Wiley & Sons, Inc., 1955 ##

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4A24804

Serial Number 2028
ASQC Codes 814;817

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Cost: a reliability factor

AUTHOR: Peter H. Fowler, ITT Communication Systems, Incorporated (present affiliation: Martin Marietta Company, Baltimore, Maryland)

SOURCE: Electro-Technology, vol. 74, September, 1964, pp. 101-103

PURPOSE: To show that cost can be important in determining reliability allocation and effort.

ABSTRACT: Rarely is reliability the only property of interest for equipment. Cost is important and must be taken into account in any decisions. An example is derived for series-parallel allocating of resources which uses cost as a factor. The parameter cost/[log(unreliability)] is used to simplify some of the algebraic expressions. The costs of course must include both capital and repair--i.e., all of the costs of ownership.

The article is a review and cites references to most of the points made.

REVIEW: This is a short article with a good message--be sure to worry about cost. Of course, other constraints such as weight could be substituted for cost. A factor of cost/[log(unreliability)] is introduced which has the property of remaining constant under parallel active redundancy. It is not fully explored but might prove to be rather useful. Some of the statements about the cost allocation in series-parallel systems are not at all obvious. Other papers on reliability and cost are found under Code 814. ##

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Serial Number 2029
ASQC Codes 823;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Extrapolating component life tests

AUTHOR: Charles Toye, Reliability Manager, Transitron Electronic Corporation

SOURCE: Electro-Technology, vol. 74, October, 1964, pp. 36-39

PURPOSE: To discuss new statistical techniques for faster and less costly reliability testing.

ABSTRACT: Reliability testing under operating conditions is prohibitive for highly reliable devices. Accelerated testing of some kind must be used. The Arrhenius relation is useful when it is applicable. If stresses other than temperature are involved, then other acceleration equations must be found. Factorial tests are quite useful, together with equation fitting, analysis of variance and contour plotting from the data.

REVIEW: The statistical techniques themselves are not new and matrix testing has been proposed before for life-testing. This is more in the nature of a review paper for those already familiar with the situation. The discussion of the Arrhenius relation is somewhat loose. In essence the multiple regression formula is an interpolation/extrapolation technique; the validity is, of course, no better than its fit to the data. In the text example, for any given set of conditions, the change in base current is a linear function of time--a fairly restrictive assumption.

The emphasis on similar failure mechanisms at elevated and operating stresses is good. ##

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Serial Number 2030
ASQC Codes 824

838

720;813;825;
833;853

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

64A16051

TITLE: Estimating Weibull-distribution parameters

AUTHOR: Joseph V. J. Ravenis II, Westinghouse Electric Corporation

SOURCE: Electro-Technology, vol. 73, March, 1964, pp. 46-54

This paper is almost identical to the one covered by Abstract and Review Serial Number 1171, yet no mention is made of the earlier publication.

64A22983

TITLE: System reliability: redundant networks

AUTHOR: G. D. Weinstock, Radio Corporation of America

SOURCE: Electro-Technology, vol. 74, August, 1964, pp. 26-29, 152

This paper is essentially the same as the one covered by Abstract and Review Serial Number 1172, although no reference is made to the earlier publication.

TITLE: Built-in reliability

AUTHOR: Frank A. Applegate, Light Military Electronics Department, General Electric Company

SOURCE: Electro-Technology, vol. 74, October, 1964, pp. 40-45

This is essentially the same as the paper covered by Abstract and Review Serial Number 1273, although no mention is made of the earlier publication. ##

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Serial Number 2031 -1
ASQC Codes 711;714;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Wear considerations in design (in seven parts)

AUTHOR: Charles Lipson, Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Michigan

64A10887

SOURCE: Machine Design, vol. 35, October 24, 1963, pp. 156-164 (Part 1), November 7, 1963, pp. 177-185 (Part 2), November 21, 1963, pp. 182-191 (Part 3), December 5, 1963, pp. 142-147 (Part 4), December 19, 1963, pp. 140-144 (Part 5), vol. 36, January 2, 1964, pp. 121-124 (Part 6), and January 16, 1964, pp. 167-173 (Part 7)

64A11352

64A10937

PURPOSE: To present basic theories of wear of metals and to treat the effect of many factors on wear.

ABSTRACT: Wear is a difficult-to-define phenomenon. Because it is more than a condition of surface degradation, wear cannot be completely described by the mathematical equations that define friction. As considered here, the concept of wear is broad and includes all deterioration with use. Contributors to material destruction by wear are not only mechanical but also metallurgical, chemical, electrical, and thermal in nature. Maximum design against wear cannot be achieved through the solution of any prescribed set of equations--no such equations exist. Combinations of material properties must be judiciously selected from experimental and theoretical data after service requirements have been analyzed. This discussion is largely limited to the wear of metals.

Part 1: Mechanism of wear, wear control, scoring and seizure. Four major models for wear are adhesion, interlocking, abrasion, and "quanta" theory. Of these, the adhesion theory best describes the phenomena of wear. Many experiments on the friction of metals and the mechanism of sliding have shown that wear may be explained in terms of the formation and subsequent breaking of metallic junctions. Friction may be reduced by the formation or addition of a low shear strength layer or by increasing flow strength of the substrates. These ends can be accomplished by increasing substrata hardness and the formation of an oxide film.

The complexity of wear is emphasized by a consideration of factors required to describe it. These include (1) variables connected with metallurgy (hardness, toughness, constitution and structure, and chemical composition), (2) variables connected with service (contacting materials, pressure, speed, temperature, and surface finish), and (3) other contributing factors (lubrication and corrosion). Furthermore, wear is usually a combination of one or more elementary forms. For example, small particles from galling action can result in abrasive wear. Or, in a press-fitted assembly, frettage corrosion can result in wear and subsequent damage.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

If other factors remain equal, wear rate generally increases with decreasing metal hardness, with increasing distance run, with increasing temperature, with lower sliding speed, and with rougher surfaces. Contaminants and the environment can act either way, depending on their specific nature. Methods used to control wear can be categorized according to the following principles: (1) principle of protective layers, (2) principle of conversion, and (3) principle of diversion.

If the bonds between the touching parts are stronger than one or both of the metals, the weaker metal fractures, and some of it adheres to the other. Transfer of metal from one part to the other causes one of the parts to be worn away. This is the mechanism of scoring. If sufficient bonds develop, the force required to break the bonds exceeds the applied operating force, and the metals are unable to slide on each other. This is the condition of seizure. Tables of scoring and siezure resistance are included.

Part 2: Surface films, lubricants, abrasion.
The adhesion theory of friction can be extended to include the sliding action between lubricated surfaces, if lubrication is in the thin-film region. In this case, the interface film is insufficient to fully separate the two sliding surfaces, and contact takes place at the penetrating asperities. Plastic flow occurs, and these highly-stressed contact points weld together. Coefficient of friction depends directly on the degree to which the surface film prevents asperity contact and on the strength of the junctures formed by the welding that does occur. Good lubricants not only have low shear strengths but reduce point welding by antiflux action. These properties decrease the friction force and the wear from metal transfer at broken asperities. Metal oxides that are dense and adherent can help resist wear. Fe_3O_4 appreciably reduces the dry wear of steels. Graphite, either in materials such as cast iron or added separately, can reduce dry wear. The atmosphere is important since moisture and/or oxygen are necessary for the good lubricating qualities.

Liquid lubricants may be either inactive, such as the common petroleum oils, or reactive and form chemical bonds with the surface. Solid lubricants such as molybdenum disulfide generally have easy slip planes in the lattice. Lead oxide is a good lubricant above $900^{\circ}F$, although it is poor at lower temperatures.

Wear by abrasion can be divided into three major categories: (1) gouging abrasion, (2) grinding, or high-stress, abrasion, and (3) erosion, or low-stress-scratching, abrasion. All three can occur simultaneously, but the type which predominates usually can be recognized. Tables are listed of the properties of metals

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and alloys for each type of abrasion.

Part 3: Residual stresses (effects on physical and wear properties, methods of control), contact stresses.
Extending the definition of wear to include all material deterioration with use (rather than limiting it to the mechanical failure of rubbing surfaces) broadens the base from which wear must be examined. Surface evidence of material failure can be misinterpreted; external effects may have internal causes. Two such causes--residual and contact stresses--are discussed in this part.

Most commercial fabricating processes develop residual stresses to some degree in the metal being processed. These residual stresses may increase or decrease the wear resistance of a material. Means for predicting the magnitude and sense of stresses that result from a particular operation have not yet been developed to a reliable state. However, applicable remedies have been devised and qualitative conclusions have been formed.

Tensile stresses are generally detrimental, especially when they occur at or near the surface; compressive stresses usually provide beneficial properties. Since there are few preventive measures available to control residual stresses, remedial methods of relief after-the-fact of stress formation are used. Most commercial stress-relief methods are either thermal or mechanical in nature. The exact relationship between residual stresses and fatigue of fabricated parts is not well defined. However, evidence favors a direct relationship, and it is generally agreed that fatigue life is affected beneficially or detrimentally by residual stress, depending on whether they are compressive or tensile and whether they occur at or below the surface. Surface compressive stresses are associated with increased life; surface tensile stresses are associated with decreased life.

Residual stresses may be controlled, i.e., service properties optimized, by special processing and heat-treating methods, by finishing operations that are properly controlled, by stress-relief annealing, and by mechanical stress relief such as surface rolling or shot peening. Contact stresses generally accelerate the process of surface deterioration.

Part 4: Corrosion and cavitation damage (mechanisms, types, and controls).
Corrosion is a galvanic action between a metal and its environment and is considered here as an element of wear. Most metals do not combine spontaneously with oxygen or other common gases under ordinary environmental conditions. The process of galvanic corrosion is much more complex than a direct oxidation reaction.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

Galvanic action may occur because of battery action due to differences in the electrochemical "strength" of the metals, or because of differences in concentration of an electrolyte for the same metal. The anode is the metal generally subject to corrosive attack. Some metals, e.g., aluminum and stainless steels, form protective coatings. The coatings are not necessarily protective in all environments. Stopping any one of the items necessary for an electrolytic cell will stop the corrosion. One must be careful, however, not to create extra problems at the same time. Other methods of control are to make the anode area/cathode area large, to keep the metals clean, to use electrode polarization, sacrificial corrosion of another metal, and cathodic protection by an electrical circuit. All of these are rather tricky to use.

Cavitation is the formation of bubbles within a fluid which has movement relative to some solid surface. When velocity changes, impressed vacuum, or fluid friction cause energy conversion in the fluid so that static pressure is reduced to the liquid vapor pressure, boiling occurs and the cavitation bubbles are formed. If the point of collapse of the cavity happens to be at the boundary surface, the wall will receive repeated impact loading. In some cases, local pressures are above the yield strength of the containing metal, and instantaneous pitting occurs. Cavitation damage can be reduced by (1) changing physical conditions that cause cavitation and (2) improving surface resistance to cavitation corrosion. If local static pressure at every point in a system is prevented from falling below the vapor pressure of the fluid flowing, cavitation will not occur. However, this is not always possible, and the second method must be used.

Part 5: Fretting, fretting corrosion, pitting.
The fretting-corrosion phenomenon has been described by a variety of names such as false brinelling, wear oxidation, chafing fatigue, and friction oxidation. Fretting is a type of scoring or abrasion which occurs when two metal surfaces are pressed together and are subjected to reciprocating motion of very small amplitude. When the surfaces, or particles from the surfaces, react with the environment, fretting corrosion takes place. Therefore, fretting can be classified as scoring, abrasion, or corrosion, depending on the particular conditions of wear. Fretting is increased as the distance of slip increases (in the range of 0.4 to 9 mils), as frequency decreases, as relative humidity decreases (in the range 0-50%), as lubrication is decreased, and as surfaces are smoother and closer together. Prevention is accomplished by good lubrication to remove oxygen, by compressive surface stresses, by putting a "gasket" between the surfaces, or by changing the loading conditions.

Theories that pitting failures start on the surface are based

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on observations of small cracks which appear on the surface and then grow until a piece of metal dislodges and a pit is formed. Although there is no clear evidence to define a precise mechanism by which the pitting cracks start, there is general agreement among investigators that the cracks are propagated by hydrodynamic wedging of lubricating oil.

Part 6: High-temperature corrosion, stress-corrosion cracking. The corrosion element of wear can be more complex than the simple oxidation reaction, which occurs at ordinary temperature, or the electrochemical process, which results from an accidentally formed galvanic cell. Two such complicated corrosion mechanisms are stress-corrosion cracking and high-temperature corrosion. At temperatures above 750F, oxidation appears to be due mainly to the direct chemical combination of oxygen with the metal. In iron and steel, this reaction leads to a complex stratification of oxides on the metal surface.

Although various definitions of stress-corrosion cracking are offered in different sources, the point in common is that the mechanism is directly linked to the combined effects of two independent phenomena, stress and corrosion. Failure of metals by stress-corrosion cracking appears in different circumstances and evidences itself in many ways. Frequently, the attack occurs without warning. For example, railroad truck wheels have exploded from the combined effects of residual stress and corrosion while in warehouse storage. Generally, localized corrosion of a part forms pits or other surface defects that affect a local stress concentration. The combined action of corrosion and stress then results in propagation of cracks initiated in areas of exceedingly high stress. Factors influencing stress-corrosion are summarized.

Part 7: Surface treatment for wear resistance: polishing, electroplating, anodizing, metal spraying, hard facing, and case hardening. Considering the many possible mechanisms of wear, it seems virtually impossible to prevent the deterioration of metal parts with use. But if surface degradation caused by mechanical or chemical attrition cannot be prevented, it can be effectively minimized by surface treatment. This is probably the most important wear consideration in design. Applications and considerations for each method are given. (Author in part)

REVIEW: This is a good comprehensive set of articles. If the reader begins with little knowledge of the subject, it will be hard reading because there is so much to assimilate. While the design engineer may not remember everything in the articles, at least he will be in a better position to understand the advice of specialists and to know when to seek such advice. ##

Serial Number 2032
ASQC Codes 815;824

G

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Parts specification and reliability

AUTHOR: J. R. Isken, International Resistance Company, 401 North Broad Street, Philadelphia 8, Pennsylvania

SOURCE: 11 pp., presented at the Canadian Electronics Conference, October, 1963

PURPOSE: To discuss three problem ares in the approach to reliability specifications.

ABSTRACT: This paper is concerned with three problems which have developed in the course of recent parts-specification-writing activity. These problem areas are:

1. Misunderstanding and misuse of the term confidence,
2. Lack of understanding of production processes, and
3. Lack of understanding of the economic and logistic impact of the statistics.

The problems are discussed and it is pointed out that the generation of realistic specifications must take into account the concept of confidence, the realities of process behavior, and logistic considerations. (Author in part)

REVIEW: This paper raises some legitimate problems, but the solutions offered are poorly expressed. In particular, it is not made clear that the connection between risk, confidence, and the operating characteristic curve is correct only if the sample size and the number of failures correspond to those used in deriving the operating characteristic curve. The uses of the terms producer's risk and consumer's risk are not in keeping with the usual terminology of acceptance sampling.

The discussion on the nature of the manufacturing process and the inadequacy of models used to describe it is not clear. In principle, it should be pointed out that statisticians propose and analyze models. The user of a model is at fault when he applies it blindly without realizing its limitations and the assumptions on which it is based. The paper offers little help on the construction of better models. Papers such as those covered by Abstracts and Reviews Serial Numbers 1287, 1291, 1852, and 1935 can introduce the reader to the approach of using prior knowledge in the development of models. These models can then be useful in creating better sampling plans. (This is called the Bayesian approach by statisticians). It must be recognized, however, that not all prior knowledge about a process is easily incorporated into useful models. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Optimal periodic inspection programs for randomly failing equipment

AUTHOR: George H. Weiss, Rockefeller Institute, New York, New York

SOURCE: Journal of Research of the National Bureau of Standards--B. Mathematics and Mathematical Physics, vol. 67B, pp. 223-228, October-December, 1963

PURPOSE: To find the optimal periodic solution for the checkout interval of a system which does not necessarily have an exponential reliability function.

ABSTRACT: There have been many analyses made of models for equipment inspection, i.e., where a system may suffer a breakdown, but such an event is only discovered by an inspection which may not be perfect. Most analyses assume that the time to failure follows a negative exponential law which implies that only periodic inspection programs need be considered. Another model which has been analyzed by Barlow, Hunter, and Proschan finds the optimal program of inspections when the equipment reliability function is of general form, but a particular loss function is given. In this paper we find the optimal periodic inspection program for systems which do not have negative exponential reliability functions. These programs have the virtue of simplicity even though they may not be optimal in an absolute sense. Besides the periodic inspection programs, we derive results for random inspection programs.

The equipment is never repaired, only replaced after a time T. The inspection interval time is Δ and a policy with the values Δ and T is denoted by (Δ,T). The (Δ,∞) where Δ is a constant and where it is a random variable, and the $(\Delta,N\Delta)$ policies are treated. (Author in part)

REVIEW: This is not as complete a treatment as might be inferred from the title but the cases considered are interesting. The paper is directed toward the theoretician rather than the design engineer. Not all of the mathematics was checked, but it seems to be of high quality. The orientation of the paper relative to other published work on the topic is indicated, and eight pertinent references are cited. ##

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Serial Number 2034
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Assessment of thermal-fatigue strength by varying the loading rate

AUTHORS: S. V. Serensen and P. I. Kotov

SOURCE: Industrial Laboratory, vol. 28, pp. 1312-1316, June, 1963 (Translated from Zavodskaya Laboratoriya, Vol. 28, No. 10, pp. 1233-1238, October, 1962)

PURPOSE: To present tests of thermal fatigue and their interpretations wherein the specimen is not rigidly clamped.

ABSTRACT: Two heat-resisting alloys were investigated for thermal fatigue under a varying rate of loading (3.3×10^5 to 0.9×10^5 kg/cm) in order to obtain thermal-fatigue curves for specified thermal conditions. The thermal-fatigue strengths of alloys, as expressed by relative fatigue curves, are compared in temperature ranges characteristic of the alloys concerned. The use of relative total-strain and relative number of cycles to failure produces a universal curve for each alloy. This makes calculation and interpretation much easier. (Authors in part) *

REVIEW: This paper is probably of interest only to those concerned with thermal fatigue. The data as such are of limited value, but the method of analysis is instructive. ##

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Serial Number 2035
ASQC Codes 711;773

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A technique for thermal-fatigue testing in the presence of a uniaxial stressed condition

AUTHORS: N. D. Sobolev and V. I. Egorov, Moscow Engineering-Physics Institute

SOURCE: Industrial Laboratory, vol. 28, pp. 1317-1321, June, 1963 (Translated from Zavodskaya Laboratoriya, Vol. 28, No. 10, pp. 1238-1242, October, 1962)

PURPOSE: To describe equipment for thermal fatigue tests wherein the mechanical strain can be larger or smaller than the thermal strain.

ABSTRACT: A method is suggested for fatigue testing of metals in which the mechanical strain can be made smaller or larger than the temperature strain. Fatigue curves were plotted for a wide range of strains corresponding to 200 to 10,000 cycles, with thermal conditions remaining unchanged. This is in contrast to the work of Serensen and Kotov (Abstract and Review Serial Number 2034) where the mechanical strain can only be less than the thermal strain. (Authors in part)

REVIEW: This is an effort to create tests more nearly simulating actual service conditions. The article may be of use to those directly concerned with simulating thermal fatigue. ##

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Serial Number 2036
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: On a relative evaluation of the thermal fatigue strength of materials

AUTHORS: V. I. Egorov and N. D. Sobolev, Moscow Engineering-Physical Institute

SOURCE: Industrial Laboratory, vol. 29, pp. 790-793, November, 1963 (Translated from Zavodskaya Laboratoriya, Vol. 29, No. 6, pp. 739-742, June, 1963)

PURPOSE: To suggest methods for comparing the resistance of materials to thermal fatigue.

ABSTRACT: Thermal fatigue is caused by cyclic stresses and strains induced by fluctuating temperatures in constrained material. The authors suggest a method for the relative evaluation of the thermal fatigue strength of materials which involves, in the case of a uniaxial stressed condition, the use of the strain or the corresponding stress with the coefficient of linear expansion taken into account. For the evaluation of this strength in the case of a complex stressed condition caused by the presence of a temperature gradient we recommend approximate criteria. (Authors in part)

REVIEW: Several formulas are given for figures of merit under different conditions. They appear to be reasonable, but no extensive experimental justification is given.

Failures due to thermal fatigue must, of course, be taken into account by designers. ##

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Serial Number 2037
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The comparison of results of short- and long-term thermal fatigue tests

AUTHOR: T. F. Balandin

SOURCE: Industrial Laboratory, vol. 29, pp. 797-799, November, 1963 (Translated from Zavodskaya Laboratoriya, Vol. 29, No. 6, pp. 746-748, June, 1963)

PURPOSE: To compare some short- and long-term thermal fatigue tests.

ABSTRACT: The author shows that the results of a special thermal fatigue test agree with the data obtained by the extrapolation of the number of cycles to rupture during short tests by Coffin's method (which takes into account the time of action of thermal stresses within a cycle). It is also shown that service life in the conditions of thermal fatigue depends, to a considerable extent, on the duration of the cycle. (Author)

REVIEW: The article is somewhat difficult to interpret without access to some of the author's references to his earlier work. There is no discussion of the type of damage involved while the material is stressed at the high temperature, although it undoubtedly is related to high-temperature creep. There is no mention of the actual strains at either the high or low temperatures. The curves do indicate, however, pronounced damage when the specimen is held at the high temperature. ##

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64A13601

Serial Number 2038
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The evaluation of the fatigue limit for long service life

AUTHORS: I. I. Trunin, M. I. Solonouts, and L. L. Chukhina, Scientific Research Institute of Technology and Machine Construction

SOURCE: Industrial Laboratory, vol. 29, pp. 803-804, November, 1963 (Translated from Zavodskaya Laboratoriya, Vol. 29, No. 6, pp. 752-753, June, 1963)

PURPOSE: To compare the results of evaluating the fatigue limit by several methods.

ABSTRACT: The results are given in this paper of the processing of a large number of experimental data on the fatigue strength of various materials by means of power equations and graphical processing in a logarithmic coordinate system. Conclusions were drawn concerning the reliable evaluation of heat-resistance properties of metals. (Authors)

REVIEW: This paper is difficult to understand since the methods are referred to only by names whose meanings are not obvious. No equations are given to clarify matters. Consequently, unless one is familiar with the terminology, the paper is of no use. ##

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Serial Number 2039
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Origin of stress failure in glass reinforced plastics

AUTHORS: P. E. Throckmorton, Midwest Research Institute, 425 Volker Blvd., Kansas City, Missouri and H. M. Hickman and M. F. Browne, Gustin-Bacon Manufacturing Company, 210 W. 10th Street, Kansas City, Missouri

SOURCE: Modern Plastics, vol. 41, November, 1963, pp. 140-146 (Breskin Publications Inc., 770 Lexington Avenue, New York 21, New York)

PURPOSE: To look into the physics-of-failure of glass-fiber reinforced plastics.

ABSTRACT: The effect of sizings and coupling agents on the mechanics of failure of E-glass reinforced plastics was studied. Photomicrographs of cyclically stressed Naval Ordnance Laboratory (NOL) ring sections showed glass-resin bond separations or stress cracks at less than 0.2μ from the glass surface. Cracks were not present in the bulk phase resin nor through the glass filaments. NOL rings from chemically finished glass strands containing vinylsilane developed higher flexural strength and showed less flexure-induced stress cracking under the microscope than rings of unfinished strands. Stress cracks did not appear to originate at resin-lean areas, which were most prevalent when the glass strands were sized in the absence of vinylsilane. The results of the study indicate that laminates fail primarily by loss of adhesion between the resin and glass filament surface, without fracture of the glass filaments. (Authors)

REVIEW: This is a "physics-of-failure" paper and makes a good contribution to that field. (However, it has little of value for the engineering-designer of structures.) ##

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Serial Number 2040
ASQC Code 830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Configuration analysis

AUTHOR: John de S. Coutinho, Grumman Aircraft Engineering Corporation

SOURCE: 14 pp., presented at the 1963 ASQC-Rutgers Conference on Quality Control, Rutgers University, September 7, 1963

PURPOSE: To present a philosophy of design analysis and comparison.

ABSTRACT: The factors affecting inherent reliability are design functions such as selection of components and materials and their skillful application; and manufacturing and distribution functions such as process selection and control, workmanship, packaging, and quality control.

Within this overall scheme, design plays a critical role. If the basic design concept is sound, but subsequent execution in manufacturing or operation is faulty, these latter deficiencies can usually be corrected after they are identified. But if the basic design itself is faulty, no matter how good the execution is, it can never make up for faulty design. In this case, after-the-fact reliability improvement programs usually can do no more than help the designer approach the reliability level inherent in the original design and which should have been achieved in the initial design cycle.

Each configuration that appears reasonable is analyzed for things like reliability, availability, weight, and vulnerability. An example of an hydraulic system for a twin-engine aircraft is used. Getting good failure data is important but difficult. Grumman uses the Navy's FUR data extensively. (Author in part)

REVIEW: The methods proposed in the paper have merit although it is difficult to find anything novel about the suggestions. A figure-of-merit for different approaches to a system is more desirable (see Abstract and Review Serial Number 1918). The present paper does not show how to weight the various factors to arrive at a single judgment.

In one place the author makes a serious error when he says that in order to have no failures in a total operating time T (and explicitly assuming the exponential distribution) the MTBF should be T. If this were followed, 63% of the planes would fail during the period, rather than none as stated by the author. Even if the distribution were Gaussian, 50% of the planes would fail. ##

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65N81873

Serial Number 2041
ASQC Codes 835;851

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability in microelectronics

AUTHOR: Ernest R. Jervis, ARINC Research Corporation, 1700 K Street, N. W., Washington 6, D. C.

SOURCE: ARINC Research Newsletter, vol. 1, July-August 1963, pp. 1-4 (From a paper presented at the Conference on the Impact of Microelectronics, 27 June 1963)

PURPOSE: To discuss ways of evaluating the reliability of microelectronic devices.

ABSTRACT: So far, it appears that an integrated circuit is about as reliable as any semiconductor device. But since this reliability is quite high, how can we estimate the very low failure rates? One approach is to consider both performance variation and catastrophic failures. If the probability density functions (pdf's) of the parameters of a device are known, then the pdf of its performance can be calculated. Monte Carlo techniques are useful here when a mathematical equation of performance in terms of parameters exists.

REVIEW: This is a most brief description although the author or his company can undoubtedly provide further information. While this paper shows a promising approach, there are some difficulties which are not mentioned. The main one is the virtual impossibility of knowing the parameter pdf's far enough out on the tails to be able to calculate the pdf of performance in the region where the very small failure probabilities are of interest. One is reminded of the technique for catching a bird: Sneak up behind it and sprinkle salt on its tail feathers. ##

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Serial Number 2042
ASQC Codes 770;801;813;
833;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Introduction to reliability, Third Edition

AUTHORS: Daniel N. Schochet and Charles C. Cullari, Associated Testing Laboratories, Inc., Wayne, New Jersey

SOURCE: Associated Testing Laboratories, Inc., 53 pp., May, 1963 (A condensation of this report is published in three parts in Environmental Quarterly, vol. 10, December, 1964, vol. 11, March, 1965, and June, 1965) but see 65A13524

PURPOSE: To present an introduction to the subject of reliability from the test engineer's viewpoint.

ABSTRACT: Four probability functions (Normal, exponential, Weibull, and gamma) are briefly discussed. Considerations for a reliability program are briefly given. Many pictures are shown to illustrate testing procedures; the procedures are discussed in some detail. The analysis of the data for assumed exponential and Weibull distributions is explained. Calculations for finding the probability of system survival from the reliability of its elements are shown.

REVIEW: The emphasis is largely on testing as would be expected from the source of the pamphlet. In that area the text is adequate. In the realm of statistics, however, anyone who expects to use the information in his calculations would do better to refer to a textbook such as [1]. For example, there is some confusion between hazard rate and failure rate. The discussions of circuit design tolerance dwell on worst case only and consider not at all the possibility of statistical design. In another case, where the exponential assumption is initially made, it is then pointed out that less than 1% should be "allowed" to fail in a time of (MTBF)/4. Obviously, if the distribution is exponential, about 25% can be expected to fail in that period. The term random process is used occasionally in the text where Poisson process is meant. In a private communication the first author has stated that the imprecise statements are being corrected in the fourth edition of the pamphlet.

REFERENCE: [1] Reliability: Management, Methods, and Mathematics, David K. Lloyd and Myron Lipow, Prentice-Hall, Inc., 1962 ##

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Serial Number 2043
ASQC Codes 833;851

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Improvements in semiconductor reliability

AUTHOR: John Bohm, Northern Electric Company Limited, 1134 St. Catherine Street West, Montreal, Canada

SOURCE: Electronics and Communications, vol. 11, November, 1963, pp. 21-23, 36, 37 (Age Publishing Company Limited, 450 Alliance Avenue, Toronto 9, Canada)

PURPOSE: To discuss an accelerated burn-in test for silicon semiconductors.

ABSTRACT: Technological progress in the semiconductor field still cannot keep pace with the demand for increased reliability, and the selection of devices is needed for high reliability applications. The best-known methods for reliable selection are actual use or its substitution by power aging, but these time-consuming processes are not practical for high-production volumes. Acceleration of power aging can be achieved by changing the electrical conditions and/or increasing the power level. Good results were obtained with these processes in a short burn-in time, and with a low screening drop-out ratio. Burn-in efficiency of 10 can be achieved during the burn-in period, and this is equivalent to increasing the life of the screened devices by 10 times. Further experiments are under way to increase the burn-in efficiency and to cut down the required burn-in time, and screening drop-out. The conclusion of the study will result in highly reliable semiconductor devices which can meet even the most severe reliability requirements. (Author in part)

REVIEW: The subject of screening and burn-in is an important one for reliability of semiconductors. The discussion of this particular method is informative. ##

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Serial Number 2044
ASQC Codes 782;833;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Power transistors: failure-rate studies influence circuit design

AUTHORS: H. Paul Root and Larry Ingle, Delco Radio Division, General Motors Corporation, Kokomo, Indiana

SOURCE: Automatic Control, vol. 18, June, 1963, pp. 16-21, 52

PURPOSE: To present failure rate and design information on power transistors.

ABSTRACT: Catastrophic failure rates of power transistors are most affected by collector emitter voltage and by temperature. The failure rates increase exponentially with both voltage and temperature: each 10°C increase multiplies the failure rate by 2.0; each increase of 10 volts multiplies the failure rate by 2.5.

Power transistors will withstand rugged physical environments as indicated by the test results. The transistors were capable of withstanding physical environments exceeding military specifications by more than 50%. Neutron irradiation effects become harmful only in the ranges of 2×10^{12} neutrons per cm.^{2}. Acoustical noise shocks up to 140 decibels have no effect upon transistor parameters. Other factors concerning environmental stresses, nuclear radiation, parameter stability and switching times can be supplied by Delco Radio for special circuit design applications.

The switching times of the 2N174 family of transistors are most affected by circuit beta and collector current while temperature and voltage have no significant effect. Delay, rise and fall times increase as collector voltage is increased. However, storage time decreases as the collector current is increased. (Authors in part)

REVIEW: This article does give useful information for designers, but it is not clear just how generally applicable the information is. For example, the results are stated for power transistors, yet even the qualification of germanium vs. silicon is not given explicitly. Nor are the results explicitly limited to Delco power transistors. No idea of the scatter in the data is given for the acceleration factors.

It would be unwise for designers to use the information in this paper for any but the transistors explicitly given by type number and, in that event, it would probably be best to correspond directly with the supplier. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The prevention of pipe failures (a series of seven articles)

AUTHOR: Helmut Thielsch, Manager, Industrial Piping Laboratory, Grinnell Company, Inc., Providence 1, Rhode Island

SOURCE: Heating, Piping & Air Conditioning, vol. 34, August 1962, pp. 98-103, September, 1962, pp. 152-158, October, 1962, pp. 120-126, December, 1962, pp. 131-140, vol. 35, February, 1963, pp. 115-119, March, 1963, pp. 104-109, and August, 1963, pp. 124-132

PURPOSE: To present a series of articles on the various factors affecting the failure of piping systems.

ABSTRACT: This is a series of articles designed to give engineers a more detailed knowledge about pipe failures and their prevention. The separate titles with brief abstracts are as follows.

1. What an engineer must know about codes, specifications and inspection for the prevention of pipe failures.
Failures of piping and tubing materials are on the increase. Although a number of factors are responsible, one of the more important involves a decreasing concern among purchasers over the quality of the pipe materials and fabrication they purchase. Where low price has become the only or primary consideration in the evaluation of quotations, the material or fabrication obtained may not meet the requirements of applicable codes and may not even represent good workmanship.

2. How proper design of a system and its weld joints aids in the prevention of pipe failures.
Piping systems generally employ materials purchased under recognized specifications. They are usually designed, fabricated, and inspected according to specific exacting codes; nevertheless, failures occur. The causes of failures in piping systems can be grouped into five general categories: design, material selection and handling, manufacturing and shaping of materials, fabrication and welding, and excessively severe conditions. Service failures primarily associated with design can be further separated into several groupings: structural design of the piping system, design notches, and joint design. In cases where design is conducive to failure, thermal fatigue and mechanical fatigue are often the causative factors in initiating cracks and propagating them across the wall thickness so that failure results.

3. Evaluation of the properties of materials and their behavior under service conditions leads to the prevention of pipe failures.
This article deals with failures that can be attributed to the improper selection of materials. It is not feasible to set forth a complete set of recommendations for material selection; examples are given of service failures which are caused by insufficient understanding of materials. A number of guides to material

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

selection are developed.

4. A discussion of common material defects--aimed at the prevention of pipe failures.

Perfect piping materials are not commercially available. Defects range from atom-sized dislocations in the metal to major metal discontinuities that are visible to the eye. Many apparent defects that are readily visible may not reduce the service life of the piping component. On the other hand, many visible surface defects and invisible subsurface defects may be harmful and result in service failures. This article deals with failures in piping materials that are caused by defects introduced by the manufacturer or processor of the metal. Such defects may have been introduced during the casting or ingot stage, or they may have developed during the subsequent rolling, forming, or reduction of the ingot or billet. Defects that result in service failures may also originate during the extrusion of pipe or during the production of fittings. Some of these defects are difficult, if not impossible, to detect during manufacture and subsequent inspection. In critical service applications, they may then be responsible for failure of the piping component.

5. Experience and integrity of fabricator are the best assurances for the prevention of pipe failures.

Pipe failures cause losses in production which frequently cost far more than the piping component that failed. This article deals with failures attributable primarily to improper fabrication, either in pipe fabrication plants or during field erection. The direct causes of this type of failure can be further separated into several groupings: bending and working of piping, end preparation for welding, welding, heat treatment, and cleaning.

6. Relate welding processes to materials and conditions for the prevention of pipe failures.

This article discusses those failures that result from the actual welding of piping components.

7. Don't underestimate importance of heat treatment and cleaning in the prevention of pipe failures.

This article deals with failures resulting from improper heat treatment and cleaning operations. (Author in part)

REVIEW: This is an intensive series on piping failures. Much of the discussion has broader applicability to many metal fabricating processes. The material is copiously illustrated.

In view of the remarks by Admiral Rickover (see Abstract and Review Serial Number 694) about many of the problems in nuclear submarines being traceable to conventional parts, this series has a special importance for designers. They may feel incorrectly that these established products and processes do not need their close attention. ##

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Serial Number 2046 -1
ASQC Codes 711;815;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failures in high-temperature high-pressure piping

AUTHOR: Helmut Thielsch, Manager, Industrial Piping Laboratory, Grinnell Company, Inc., Providence 1, Rhode Island

SOURCE: Nuclear Safety, vol. 4, March, 1963, pp. 1-24

PURPOSE: To give both an extensive and intensive discussion of the causes of failures in piping for nuclear reactors.

ABSTRACT: Pipe is pipe! Its application in a commercial steam power plant, nuclear power plant, refinery, or chemical plant is usually based on identical or very similar design considerations. Materials of the same mechanical and physical properties, chemical compositions, and metallurgical structures are used. Fabrication procedures, such as bending, shaping, welding, and heat-treatment, involve identical techniques, which depend on the final quality desired and not on the type of application. Finally, inspection by radiographic, ultrasonic, or other techniques does not differentiate, for example, between nuclear and commercial power plant piping applications.

As increasingly severe service requirements are being imposed on the materials used, service failures are becoming more frequent. A substantial number of steam power plants now have as much as 10 to 20% of their producing capacity idle because of service failures. These include not only failures in piping but also failures in boilers (boiler tubing), turbines, and other equipment essential to the safe operation of the power-producing unit.

The service requirements in nuclear power plants have involved lower temperatures than those of modern steam power plants. Nevertheless, service failures in nuclear plants are viewed with extreme concern, particularly where the leakage of radioactive materials might lead to contamination and thus hazardous conditions for the replacement or repair of the pipe section containing the failure. In extreme instances a whole section, building, or even area might become inaccessible because of leakage resulting in radiation levels in excess of safe limits.

Service failures in piping systems are usually associated with at least one of the following five factors: (1) design, (2) material selection and handling, (3) manufacturing and shaping of materials by the mill, (4) final fabrication and welding in the pipe fabrication plant or during erection, and (5) excessively severe service conditions.

In some instances a cause of failure can be related to a combination

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of several of these factors. For example, a pipe weld containing root defects, such as lack of penetration, may not fail during service until thermal or mechanical fatigue of unexpected severity causes propagation of the existing notch across the weld thickness. (Author in part)

REVIEW: This is a good, though rather long, article. It is extensively illustrated to make the points clearer. This is somewhat similar to the papers covered by Abstract and Review Serial Number 2045, and that review applies also to this paper. ##

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Serial Number 2047 -1
ASQC Code 824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Mathematical models for reliability testing in a nuclear radiation environment

AUTHOR: T. Johnson, Chance Vought Corporation, Aeronautics and Missiles Division, Post Office Box 5907, Dallas, Texas

SOURCE: 7 pp., presented at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Canada, June, 1963 (IEEE Conference Paper CP63-1079)

PURPOSE: To derive an estimate of reliability for use in small-sample testing based on the current state-of-the art in radiation effects.

ABSTRACT: The exponential and Weibull distributions are widely used to represent failure times. The confidence intervals associated with reliability are disconcerting to many people. An expression for reliability is derived which uses the test data and does not have a confidence statement associated with it.

REVIEW: In this paper the author appears confused with regard to the use of point estimates and interval estimates. An estimate of a parameter can be obtained as a particular value (point estimate). Alternatively, an interval can be estimated about which it can be asserted with a certain probability that the interval includes the true value of the parameter. In the latter case, the probability that the interval includes the true value is called the confidence level; in the former case, because of its nature, no confidence statement is necessary or feasible. Point estimates are particularly easy to make, although the properties of just any estimate may be quite poor.

If the author wishes to avoid statistical confidence intervals, he may readily do so by using a point estimate; there is nothing magic about it. For example, the maximum likelihood estimate (albeit biased) for reliability in the case treated by the author is simply (for the exponential case)

$$\hat{R} = \exp(-r_o t_o/T),$$

where t_o is the mission time, r_o is the number of failures at which the test is stopped, and T is the total testing time for the r_o failures. It is very simple to derive. If the author desired an unbiased estimate (which is also minimum variance, complete, and sufficient), he could have used the results of Pugh (see Abstracts and Reviews Serial Numbers 1103 and 1115), viz.,

$$R^* = (1 - t_o/T)^{r_o - 1}, \quad t_o < T;$$

$$= 0 \qquad , \quad t_o \geq T.$$

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The formula is readily extended to the Weibull distribution by using t_o^{β} instead of t_o and using $\Sigma_i T_i^{\beta}$ instead of T (where T_i is the operating time for the i th equipment).

The error in the author's derivation arises not from incorrect algebra but from treating t_o as a constant part of the time and as a continuous variable with range 0 to ∞ the rest of the time. (Of course the answer in the paper, $R' = [1 + (t_o/T)]^{-r_o}$, is one estimate of R, although its statistical properties are not known.) ##

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Serial Number 2048 -1
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Investigation of microwave window failure mechanisms and their elimination

AUTHORS: D. B. Churchill and E. W. Cheatham, Electron Tube Division, Sperry Gyroscope Company, Division of Sperry Rand Corporation, Great Neck, New York

SOURCE: Sperry Report Nr. NA-8240-8338, 121 pp., February, 1963, Final Report covering the period 1 October 1960 through 31 December 1962, Contract Nr. DA 36-039 SC-87389, U. S. Army Electronics Research and Development Laboratory, Fort Monmouth, New Jersey (DDC AD No. 409449)

PURPOSE: To make a final report, for a two-year period, on a research and development program for the improvement of microwave waveguide windows.

ABSTRACT: Independently, manufacturers have made little progress in gaining an understanding of the mechanisms involved in microwave window failures. This investigation is an attempt to combine data on window failures from all available sources and to develop windows which are adequate for new microwave devices.

A survey of current tube window technology showed that some failures could be attributed to inadequate structural designs, and others to the use of inferior dielectric materials. Most window failures are attributed to the heat and erosive effects produced by electronic discharge at the window surface. The relatively high secondary-emission coefficients of dielectric materials promote multipactor discharge. Gas and other contaminants increase the secondary yield and accelerate surface damage. Ceramic bodies that contain several percent of silicates and other additives appear to be highly susceptible to puncture. Tests have shown that sapphire is more resistant to the corrosive effects of an electronic discharge and is mechanically stronger than most dense sintered alumina, the most widely used window material. Beryllia has ten times the heat conductivity of alumina and may become the best window material.

The problem of spurious-mode resonances in window structures was separated into two parts--trapped-mode resonances and ghost-mode resonances. The factors responsible for excitation of resonant modes have been identified, and methods of circumventing some of the resonances were developed.

Filter windows offer the over-all combination of properties for broadband high-power applications. A double-disc filter window was developed and tested at the highest available peak-power density without apparent damage. The window had a relative

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bandwidth of approximately 19 percent.

Tests with evacuated waveguide sections sealed by windows (windowtrons) showed that peak-power densities of a few Mw per square inch were sufficient to cause surface damage to certain types of windows. A structure designed to produce normally directed components of electric field on each side of a test window separating two evacuated regions demonstrated an excessively high temperature rise resulting from electronic discharge on both window surfaces. (Authors in part)

REVIEW: This report should prove useful to manufacturers for improving the reliability of microwave windows, especially in high-power applications. It should be noticed that this is not only a survey; methods and instrumentation were developed to study window phenomena.

For those not familiar with the term "multipactor" there is a vague explanation on page 61 with a further reference to a journal article.

The first author, in a private communication, has advised that Contract DA-36-039 SC87389 was followed by Contract DA-36-039 AMC-02161 (E), and that the Final Report, entitled "Superpower Microwave Windows," furnished in January 1964 by Sperry Gyroscope Company to U. S. Army Electronic Research and Development Laboratories, Fort Monmouth, New Jersey, covers material supplemental to that covered by the above report. He has also indicated that the work on window multipactor discharge is continuing at the present time under Contract DA-28-043-AMC-00373 (E) at the Sperry Electronic Tube Division, Gainesville, Florida, and a final report will be furnished to U. S. Army Electronics Command about October, 1965. ##

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Serial Number 2049 -1
ASQC Codes 715;782;833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Radiation effects on microwave devices

AUTHOR: E. P. Plankis, Power Tube Department, General Electric Company, Schenectady, New York 12305

SOURCE: Report No. 8, 184 pp., Final Report, 1 July 1961 through 30 June 1963, Contract No. DA 36-039 SC-87253, U. S. Army Electronics Research and Development Laboratories, Fort Monmouth, New Jersey (DDC AD No. 423158) see also 63X14276.

PURPOSE: To evaluate the effects of pulsed nuclear radiation on voltage-tunable magnetrons and traveling-wave tubes.

ABSTRACT: The report includes a literature search on the effects of irradiating the devices and the materials of which they are made and experimental studies on voltage-tunable magnetrons being irradiated.

The effects of irradiating three magnetrons, General Electric Nos. Z-5312, Z-5337, and Z-5428, with peak gamma dose rates of 2×10^7 rads per second and peak neutron fluxes of 10^{17} neutrons per square centimeter-second are described. The effects on parameters of the Z-5312 package operating in air and nitrogen are compared. Radiation effects on the other packages are discussed, and a comparison of the construction for the three types of packages in relation to their behavior when irradiated is included.

The following conclusions are reported:

TASK 1 - VOLTAGE TUNABLE MAGNETRONS

1. The Z-5428 VTM packages are operable at peak gamma dose rates of 2.05×10^7 rads/second and peak neutron fluxes of 1.14×10^{17} neutrons/CM^2/second. The maximum radiation levels in which this VTM type will operate normally are not yet known.
2. The Z-5428 VTM was subjected to nine bursts during the test series. Neutron radiation levels up to 1.09×10^9 rads/second and gamma radiation of 2.05×10^7 rads/second were imposed upon the Z-5428 VTM, with normal operation during and after all bursts.
3. The Z-5337 VTM package was subjected to six individual radiation bursts ranging in gamma intensity from 1.76×10^6 rads/second to 1.88×10^7 rads/second and in neutron intensities from 2.23×10^7 rads/second to 2.58×10^8 rads/second. The outstanding parameter variation was an increase of 0.1 watt above the normal 4.0-watt power-output level, a change of 2.5 per cent. This variation which lasted for 100 microseconds occurred on the first radiation burst but was no longer evident during subsequent bursts,

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indicating a radiation "hardening." This may have been a cable phenomenon.

4. Tube orientation in relation to the pulse reactor did not affect the operational behavior of the Z-5337, Z-5312 and Z-5428 VTM packages.

5. Two Z-5428 VTM packages and two Z-5337 VTM packages were subjected to four radiation bursts each, ranging in gamma intensities from 1.31×10^6 rads/second to 3.35×10^7 rads/second and in neutron levels from 3.39×10^{15} neutrons/CM^2/second to 1.36×10^{17} neutrons/CM^2/second. Observation of the noise parameter and the power spectrum reveals normal operation of all four VTM packages during and after the radiation burst.

6. Since all three types of VTM packages were similar in construction, RF cavity, coupling, DC circuitry, etc., the outstanding technique to reduce radiation effects on VTM operation is the silicone-rubber potting of all possible leads and circuitry.

7. Part of the effects seen on the DC parameter may have been due to transients induced in the DC leads. These leads with voltages applied make excellent collectors for the products of ionization. This is especially true in the unpotted Z-5312.

8. All tube materials utilized in the three VTM packages have shown no signs of deterioration, although some packages have been exposed to nine radiation pulses at the Sandia Pulse Reactor Facility.

9. There have been no permanent effects on any of the VTM packages tested. The packages which were affected assumed normal operation in milliseconds after the radiation pulse. Some radiation "hardening" was apparent in that effects due to the first radiation pulse were reduced and remained consistent for subsequent radiation pulses.

10. The parameter variations of the Z-5312 VTM package surrounded by air showed a 64 per cent increase in power output and a frequency decrease of 15 megacycles from its 2000-megacycle operation. The Z-5312 VTM package sealed with a nitrogen atmosphere exhibited a power-output increase of 21 per cent with no change in frequency. In both cases, the first radiation burst produced effects on the Z-5312 VTM which were considerably greater in magnitude and duration than the following bursts. After the first burst, the VTM operation was consistent for all subsequent bursts.

11. The main construction difference between the two VTM types, from the standpoint of radiation resistance, is the silicone-rubber potting of all leads and part of the tube itself in the Z-5428. The Z-5312, which uses silicone-rubber tubing for insulation purposes, is prone to ionization effects such as those caused by gamma radiation.

TASK 2 - TRAVELING-WAVE TUBES

1. Traveling-wave tube material characteristics should not

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be adversely changed, and the tube should not become a radiation hazard in the environment of the Sandia Pulse Reactor Facility.

2. The experimental procedure (developed in this report) should adequately monitor all pertinent traveling-wave tube parameters during operation in a nuclear environment.

SIGNIFICANCE OF PROGRAM RESULTS

1. In relation to the design of electronic equipment that may experience nuclear radiation, the Z-5428 Voltage-Tunable Magnetron (VTM) package would be a highly desirable component. Its performance as an electronically-tuned oscillator operating in S-band at 10 watts output was not affected in radiation environments up to 10^7 rads/second of gamma intensity and 10^{17} neutrons/CM^2/second of fast-neutrons.

2. In relation to the mechanisms of effects of nuclear radiation on electronic devices, the changes in anode current in Z-5312 VTM package were associated with changes in the frequency of operation. This is the "pushing" phenomena to which magnetrons are susceptible. Then, changes in anode current appeared with variations in power output on the Z-5312. The Z-5428 VTM package which exhibited no changes in power output or frequency was also free of anode-current variations.

3. In relation to the design of microwave devices, it is desirable to pot exposed leads or parts of the device itself with materials such as silicone rubber. This reduces the effects of radiation-produced ionization by excluding the products of ionization from the immediate vicinity of potential collectors of these products. (Author in part)

REVIEW: All of the papers coming from the literature search are listed in the report. The information determined in the experimental study is carefully presented but is not extensive.

There is no attempt to relate the type of radiation used in the tests to that found in a typical satellite or missile application for electronic components and operating circuits.

The perspective of this report should be remembered. Ordinarily one would first study a whole device to obtain ideas. Then for a definitive study it would be necessary to make detailed tests on the elemental parts.

The report is difficult to read since it seems like a detailed transcription of a laboratory notebook. ##

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65N20518

Serial Number 2050
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: "Solder ball" formation in silicon alloy transistors

AUTHORS: E. B. Hakim, L. K. McSherry, and B. Reich, Solid State and Frequency Control Division, U. S. Army Electronics Laboratory, Fort Monmouth, New Jersey

SOURCE: Proceedings of the IEEE, vol. 53, p. 389, April, 1965 (correspondence)

PURPOSE: To describe a study of a failure mode in silicon alloy transistors.

ABSTRACT: An important source of failure in alloy silicon transistors has been the formation of "solder balls" which short the emitter-base junction. The following conclusions have been obtained from a recent study of this failure mode.

1. Balls are formed as a result of temperature in excess of 230°C (melting point of tin).
2. These temperatures are reached either by electrically induced hot spots or by external heating of the device.
3. Analysis of the balls has shown them to be 99 per cent tin, which is the main ingredient of the emitter and base regions.
4. Electrical parameters initially are not degraded by formation of balls.
5. The balls are physically attached to the device until mechanically jolted loose. (Authors in part)

REVIEW: This failure mode analysis is a good outline of the detective work which was required. The evidence presented supports the conclusions and the case can be closed for the particular type of transistors studied. Caution should be used in applying this to all alloy transistors, however, since tin is a requirement of the mode described. Other alloy structures may or may not exhibit similar behavior. ##

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Serial Number 2051
ASQC Codes 220;823

R E L I A B I L I T Y A B S T R A C T S
A N D T E C H N I C A L R E V I E W S

TITLE: Sampling inspection for life and reliability

AUTHOR: Henry P. Goode, Cornell University, Ithaca, New York

SOURCE: Transactions Twenty-First Annual Quality Control Conference, Rochester Section, American Society For Quality Control, Rochester, New York, March 23, 1965, pp. 10-28

PURPOSE: To outline in simple terms the mathematical procedures underlying the basic forms of sampling inspection plans currently employed for life and reliability evaluation.

ABSTRACT: This paper outlines some approaches to sampling inspection for procurement when life and reliability are the properties of interest. The necessity for the use of statistical techniques is discussed in terms of the need to reach decisions from the information in small samples drawn from populations in which considerable variability exists. The typical failure rate curve ("bathtub" curve) is described. Attributes and variables sampling plans based on the exponential distribution are discussed. Operating characteristics and sample size determination are explained. The Weibull model and its uses are presented. Mean life plans, hazard rate plans, and reliable life plans, all based on the Weibull distribution are discussed.

The paper includes no actual sampling plans, but references to sources of these are cited.

REVIEW: This is a good tutorial paper on sampling inspection for life and reliability. As such, it presents no new material, but it is a clear and straightforward discussion of the underlying mathematical procedures. It will be useful to those who have to use the sampling plans and wish to have a good working knowledge of the background for them. ##

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Serial Number 2052
ASQC Codes 770;782;837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The probe test--a philosophy and a technique

AUTHOR: H. Walter Price, Chief, Reliability Branch, Harry Diamond Laboratories, Army Materiel Command, Washington, D. C. 20438

SOURCE: Transactions Twenty-First Annual Quality Control Conference, Rochester Section, American Society for Quality Control, Rochester, New York, March 23, 1965, pp. 141-185

PURPOSE: To describe a technique designed to discover gross unreliabilities and their primary sources with a small sample size.

ABSTRACT: In a previous paper (see Abstract and Review Serial Number 25, p. 9) the author described the basic concept and technique of the probe test. Refinements which have recently been made are discussed in the present paper.

Domain representation for single and multiple stresses is described. It is shown that the probe test can determine whether the required performance domain lies within the actual performance domain but cannot determine how far it is within. This reduced information requirement results in a relatively small sample-size requirement. The following three environmental stresses which are usually most relevant to electronic equipment are considered: temperature, mechanical stress (shock, vibration, acceleration), and electrical stress (voltage). The test-sampling procedure is described. The problem of allocating test effort so as to obtain the optimum information for the question at hand is discussed. The probe test is described as a weak-link test technique, as a simultaneous environment test, and as a pre-cursor test to a series of diagnostic tests. The philosophy of the probe test is compared with that of MIL-STD testing. The problem of sampling for the probe test is discussed. Steps in planning a probe test are outlined. The analysis of the results is described in terms of an example.

It is stated in conclusion that the probe test will (1) determine weak-links, (2) determine that a high reliability goal has not been met, and (3) determine which stress fields (and combinations thereof) are likely to cause the most failures, but that it will not (1) determine that a high reliability goal has been met, or (2) measure the reliability of the equipment.

REVIEW: This is a detailed description of a technique for spot testing equipment when limited facilities are available. The technique appears to have much merit, as well as some deficiencies. The author has described both the merits and the deficiencies quite well. This systematic approach has much to recommend it over the more usual intuitive methods, especially for application to expensive, complicated and repairable types of equipment. ##

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Serial Number 2053 -1
ASQC Codes 782;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Laboratory techniques for the study of ultraviolet radiation effects

AUTHORS: L. A. McKellar, J. V. Steward, and R. L. Olson, Lockheed Missiles and Space Corporation

SOURCE: The Journal of Environmental Sciences, vol. 8, February, 1965, pp. 22-26

PURPOSE: To describe a laboratory program for the study of the effects of ultraviolet radiation on engineering materials.

ABSTRACT: Routine space simulation ultraviolet degradation studies generally involve exposing materials to near ultraviolet energy from a high-intensity, high pressure arc source; specimens are in a vacuum environment varying from 5×10^{-5} to 9×10^{-8} torr. Material properties of interest are determined before and immediately after the test, and a crude prediction of stability in space is made, based on the data obtained. These techniques are reasonably fast. In one week with three chambers LMSC can expose 40 samples of thermal control surfaces to exposures varying from a simulation of 100 hours to 600 hours of normally incident solar radiation, and evaluate the results. Such speed is desirable for material screening and development. The primary drawback results from the dissimilarity of the output of all suitable high intensity sources from the solar spectrum. This dissimilarity makes precise prediction of behavior in space impossible, based on the routine data alone. An additional problem is the recovery from certain forms of ultraviolet damage in the presence of air and light, which can affect the material property determinations performed subsequent to the tests.

Experiments are required to obtain further information on the variation of ultraviolet damage with wavelength, temperature, irradiance, and ambient pressure. The results of these investigations should give one insight into the mechanisms of ultraviolet damage.

Further studies on simultaneous thermal cycling and ultraviolet irradiation are of interest, since one of the effects of ultraviolet energy is embrittlement of some organic polymers. Measurement of the appropriate material properties concurrent with ultraviolet irradiation in vacuum should be performed. The final key and ultimate arbiter in the general area of spacecraft material development will obviously be the behavior of materials in the actual space environment. The cheapest way to obtain such data is through satellite-borne experiments, some of which are in progress.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

The discussion in this paper covers the environmental model, controlled variables, ultraviolet radiation sources, detectors, and sample enclosure. Seven references are cited. (Authors in part)

REVIEW: This is a well-written, concise paper on a topic of practical importance for reliable space vehicle design. The references will serve a good purpose for those who desire more details. As the authors have indicated, laboratory programs will not provide all of the needed information; however this one should do much to advance the state of knowledge in the field of ultraviolet radiation effects. ##

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Serial Number 2054
ASQC Codes 782;835;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Integrated avionics

AUTHORS: (Staff Report)

SOURCE: Space/Aeronautics, vol. 43, March, 1965, pp. 46-51

PURPOSE: To describe the problems caused by the growing scope and complexity of avionic functions, and some of the means available to solve these problems.

ABSTRACT: The continued proliferation of electronics on aircraft threatens payload capacity and reliability. To get fewer and smaller packages with longer life expectancies calls for vigorous exploitation of both integrated systems and microcircuits.

Evidences of the increasing complexity of avionic equipment are cited in the trend toward automatic and adaptive subsystems, and research and development work in optics and cryogenics. It is pointed out that economies in weight and size can be achieved through the integration of subsystems. The sharing of centralized computers, the use of multi-mode phased array radars, and the standardization of circuit components are cited as areas to be exploited. Reference is made to the Army-Navy Instrumentation Program and the Navy's Integrated Light Attack Avionics System program. The growth of avionics is depicted in chart form, on the basis of typical requirements for high-performance military craft.

The advantages of microcircuits in terms of weight, size, low power requirements, and reliability are described. The disadvantages of redundancy as a means for reliability improvement in microavionics are cited. These disadvantages include difficulty in fault isolation and repair, vulnerability to a common overstress condition, and the existence of weaknesses in common among items from the same batch. The role of modular design in improving maintainability is described. Reference is made to the problems caused by interconnection density, electromagnetic interference, and the excessive heat generated in integrated circuits.

REVIEW: This is a compact treatment of a subject which has many facets, any of which could be discussed at considerable length. It will be useful in giving designers a bird's-eye view of trends, problems, and some of the potential solutions in this field which will become increasingly important as progress continues. ##

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65A24172

Serial Number 2055
ASQC Code 775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Acoustic emission predicts static and fatigue failure

AUTHOR: Bradford H. Schofield, Senior Project Engineer, Lessells & Associates Inc.

SOURCE: Space/Aeronautics, vol. 43, April, 1965, pp. 63, 64, 66

PURPOSE: To report on developments in the use of low-level acoustic emission from metals as a sensitive tool for the nondestructive evaluation of metals and structures.

ABSTRACT: Work in progress indicates that the phenomenon of acoustic emission from metals can be put to immediate use in such endeavors as proof testing of missile casings. It can give test technicians an indication of impending failure in time to prevent catastrophic consequences.

Whereas the conventional strain gage is limited essentially to the elastic range of materials, the acoustic emission technique provides information of a qualitative nature in the plastic deformation range. Unlike the strain gage, the acoustic technique does not provide quantitative data, but it does sense plastic deformation wherever it may occur in the specimen--that is, it is not necessary to know where points of failure are likely to occur in order to predict failure. This gives acoustic emission an advantage where structures are extremely complex, or where parts are inaccessible to other types of instrumentation. Ultimate development of the acoustic technique may result in a remote stress-strain indicator that uses an acoustically emissive coating on the structure to be analyzed.

Some tests on cylindrical tanks, involving studies of the acoustic emission phenomenon in relation to both noncyclical and fatigue loading, are briefly described. (Author in part)

REVIEW: This is a brief but clear description of a potential nondestructive testing technique which appears to hold considerable promise for detecting impending static and fatigue failures in metal structures. As the author has indicated, test techniques are still under development, and the full spectrum of potential applications is yet to become clear.

For a more detailed paper on acoustic emission from metals see [1]. See also Abstract and Review Serial Number 1093.

REFERENCE: [1] Acoustic emission from metals--its detection, characteristics and source, by Bradford H. Schofield, Proceedings of the Symposium on Physics and Nondestructive Testing, San Antonio, Texas, October, 1963, pp. 63-91 ##

Serial Number 2056
ASQC Codes 773;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: New 5-second resistor test replaces burn-in

AUTHOR: Donald D. Vanous, Dale Electronics, Columbus, Nebraska

SOURCE: Electronic Procurement, vol. 5, February, 1965, pp. 23-24

PURPOSE: To describe a 5-second test for determining the quality of wire-wound resistors.

ABSTRACT: A large power is applied to the resistor for about five seconds and its resistance change with time is observed. A good resistor will change its resistance linearly with time up until power cut-off then rather abruptly drop back to its original value. Resistors which are not good in some way will deviate appreciably from this normal behavior. Different defects show up differently. Temperature coefficients can also be checked by the same test.

REVIEW: From the description of the test, it appears to be very good. Whether or not use experience will show up deficiencies in it is something else again. Development of this type of short "quality" test should be encouraged, especially where the defects eliminated would have caused short life. The discussion of temperature coefficient testing is not too complete, but apparently at least for a go/no-go gage it is satisfactory.

In a private communication the author has stated that a more complete paper was given at the 1965 Electronic Components Conference. In that paper it is pointed out that the test is applicable to many types of resistors in addition to wirewounds, and that the resistance time curve is not linear for many materials. The curves in the original text are for the case of complete power cutoff after the five seconds and show the characteristics of the recorder only (with zero input voltage). ##

Serial Number 2057
ASQC Codes 300;810

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Guaranteed reliability--Part IV

AUTHOR: R. E. Kirby, Westinghouse Corporation, Pittsburgh, Pennsylvania

SOURCE: Industrial Quality Control, vol. 21, p. 557, May 1965

This is essentially the same as the third part of the set of papers covered by Abstract and Review Serial Number 1652. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Nonparametric method in operating life testing

AUTHOR: E. P. Virene, The Boeing Company, Seattle, Washington

SOURCE: Industrial Quality Control, vol. 21, pp. 560-561, May, 1965

PURPOSE: To discuss the analysis and evaluation of test data obtained during the operating life testing of equipment by the application of nonparametric statistics.

ABSTRACT: Statistical methods involved in the life testing of equipment to determine the reliability level often assume the applicability of the exponential distribution for the operating life of equipment. This assumption is not always justified. A means of avoiding this problem is provided by the application of nonparametric statistics, i.e., statistics in which no assumption is made concerning the distribution of operating life of the equipment. This results in some loss of efficiency as compared with the situation in which the form of the distribution is known.

A table is given, showing the sample size, n, required in a life test to provide W% probability that fewer than K% of future units will fail in time less than the shortest recorded life length in the life test data. The equation on which the tabled values are based is given in an appendix, and a reference to the underlying theory is cited. Two illustrative examples are given.

REVIEW: This is a very brief paper, but it accomplishes its purpose quite well. The examples serve a good purpose for the user of the method, while an appropriate reference is cited for those who wish to delve deeper into the underlying theory.

The author has quite properly referred to the possible loss of statistical efficiency when this method is used. It would be interesting to study the question of just how serious this condition can be when the exponential distribution is in fact valid for the life-test situation considered. A more complicated question is that of how the method performs as compared to the use of a method based on the exponential when in fact some distribution other than the exponential validly describes the life times under study.

One difficulty with any method which assumes no underlying distribution of operating life is that it provides no basis for extrapolation to longer life than tested. ##

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Serial Number 2059
ASQC Codes 833;836;837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An effective design analysis program

AUTHOR: A. C. Littleford, Sandia Corporation

SOURCE: Transactions 4th Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, March 20, 1965, pp. 13-29

This paper is very similar to the one covered by Abstract and Review Serial Number 1190. ##

but see 64A15946

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Serial Number 2060
ASQC Codes 552;837;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: On reliability safety margins

AUTHOR: Austin J. Bonis, AC Spark Plug, The Electronics Division of General Motors, Milwaukee, Wisconsin

SOURCE: Transactions 4th Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, March 20, 1965, pp. 31-52 (also Industrial Quality Control, vol. 21, pp. 645-649, June, 1965)

PURPOSE: To describe reliability safety margins and discuss their importance.

ABSTRACT: A reliability safety margin is defined as the ratio of the true mean time between failures (MTBF) of the system to the specified MTBF for that system. For example, if your company can deliver a system to the customer that has a true MTBF of 2,000 hours against a requirement of 1,000 hours, then your system has a safety margin of two.

A chart on test time (fixed), failures, MTBF's, risks, and confidence limits (based on the exponential distribution) is presented. An example indicates how the chart should be used. Within the time and risks allowed, it is shown that an engineer must design a 6500-hour system to meet a 2500-hour requirement (i.e., a safety margin of 2.6 is required). It is shown that an auxiliary use for the chart is to find confidence limits. Illustrative examples are given.

A second chart, reliability operating characteristic curves (based on the exponential distribution), is presented. This chart is used in determining producer and consumer risks, and chances for incentive fees. Illustrative examples are given.

Relevant derivations are given in appendices; seven references are cited.

REIVEW: This is an expanded version of the paper by the same author covered by Abstract and Review Serial Number 1615. While the emphasis is still on the practical aspects of how to use the charts, the references and appendices are helpful for those who wish to be informed on the background material. The discussion and examples are clearly presented, and the paper should be of value to systems engineers and others concerned with reliability safety margins. The charts constitute a handy tool for both reliability engineers and managers--the kind of tool which has a proper place in a reliability handbook. (See also Review Serial Number 1615.)
##

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7/65

Serial Number 2061
ASQC Code 811

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Organizing for effective reliability control

AUTHOR: Stanley A. Rosenthal, Director, Reliability and Quality Assurance, Kollsman Instrument Corporation, Elmhurst, New York

SOURCE: Transactions 4th Annual Quality Control-Reliability Conference, sponsored by Long Island Section, ASQC, Hempstead, Long Island, New York, March 20, 1965, pp. 109-122

PURPOSE: To review the basic requirements for a complete reliability control program.

ABSTRACT: Effective control of the reliability and quality of modern aerospace systems necessitates an organized program covering all aspects of conception, design, development, and production. The successful implementation of reliability control necessitates a structure which provides for continuous close coordination among the reliability, quality control, engineering, and manufacturing operations without jeopardizing the independent role of the reliability and quality control functions. Such a structure can only be organized with the full cognizance and support of an enlightened top management.

Topics discussed in this paper include the following:

- Reliability organization and program plan
  - Reliability program plan
  - Reliability prediction
- Reliability design control
  - Reliability design review
- Parts' reliability specification and improvement
  - Comparative evaluation
  - Acceptance testing
  - Part/lot traceability
- Reliability production surveillance and control
  - Manufacturing and test surveillance
  - Failure data reporting
  - Failed parts analysis
  - Corrective action
- Reliability evaluation
  - Reliability estimates
  - Reliability testing

(Author in part)

REVIEW: This paper accomplishes its purpose of presenting a brief review of the principal elements of a complete reliability control program. It will be of interest to those concerned with organization for effective management of a reliability function. While the details may vary from one company to another, the basic principles have general applicability. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Mathematical Theory of Reliability

AUTHORS: Richard E. Barlow, University of California at Berkeley and Frank Proschan, Boeing Scientific Research Laboratories, Seattle, Washington, with contributions by Larry C. Hunter, Sylvania Electronic Defense Laboratories, Mountain View, California

SOURCE: John Wiley & Sons, Inc., New York, 1965, xiii + 256 pp., $11.00

PURPOSE: To present a survey of some mathematical models useful in solving reliability problems.

CONTENTS: Introduction: Historical background of the mathematical theory of reliability. Definitions of reliability.
Failure distributions: Introduction. Typical failure laws. The exponential as the failure law of complex equipment. Monotone failure rates. Preservation of monotone failure rate. Additional inequalities. General failure rates.
Operating characteristics of maintenance policies: Introduction. Renewal theory. Replacement based on age. Comparison of age and block replacement policies. Random replacement. Repair of a single unit.
Optimum maintenance policies: Introduction. Replacement policies. Inspection policies.
Stochastic models for complex systems: Introduction. Markov chains and semi-Markov processes. Repairman problems. Marginal checking. Optimal maintenance policies under Markovian deterioration.
Redundancy optimization: Introduction. Optimal allocation of redundancy subject to constraints. Application to parallel redundancy model. Application to standby redundancy model. Complete families of undominated allocations. Optimal redundancy assuming two types of failure.
Qualitative relationships for multicomponent structures: Introduction. Achieving reliable relay circuits. Monotonic structures. S-shaped reliability functions for monotonic structures. k-out-of-n structures. Relationship between structure failure rate and component failure rates.
Appendix:
1. Total positivity
2. Test for increasing failure rate
3. Tables giving bounds on distributions with monotone failure rate.

References: (175 published papers, reports, and books)

REVIEW: This is a research monograph in which a number of mathematical models in reliability theory are presented and analyzed. The treatment is at an advanced level, and the reader will require a sound background in calculus and probability theory in order to understand and appreciate it. Within this framework, it is a

RELIABILITY ABSTRACTS
AND TECHNICAL REVIEWS

very competent and well-written piece of work, and represents a worthwhile contribution for the use of theoreticians working in reliability and related areas.

The book will not be directly useful to practicing reliability engineers. There is little emphasis on the practical significance of the results obtained, and only a few examples are given. These facts do not represent deficiencies within the terms of reference which the authors have set for themselves; they do set limits on the areas of usefulness of the work.

The authors make clear the nature and intent of the book in the preface. In particular, it is indicated that the models presented are probabilistic rather than statistical. That is, the concern is with mathematical properties rather than with estimation or hypothesis testing on the basis of observed data.

The title of the book must be regarded as an exclusive rather than an inclusive description of the contents. That is to say, not all topics in the mathematical theory of reliability are included. This reflects the natural tendency of authors to select material for works of this kind on the basis of the mathematical tractability of the models and personal interest in working with them, rather than on the basis of meeting the needs of practical situations. ##

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Serial Number 2063
ASQC Codes 821;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: On a new calculation method for the over-all system reliability

AUTHOR: Eisuke Midzuta, Central Research Institute of Electric Power Industry, Komaecho, Kitatamagun, Tokyo, Japan

SOURCE: Proceedings of the IEEE, vol. 52, p. 1057, September, 1964, (correspondence)

PURPOSE: To show how to calculate system reliability.

ABSTRACT: A method of calculating over-all system reliability is presented. It consists of the following four basic steps:

1. Find all possible success paths in the system.
2. For each path, take the union (logical sum) of the failure events for the elements.
3. Take the intersection (logical product) of the failure events for the separate paths as found in Step 2.
4. The unreliability is the probability of the event in Step 3; i.e., there is no success path through the network included in the event of Step 3.

REVIEW: This method may appear new, but that is just because it is used so seldom in simple examples and methods. It is the one of which the others are special cases. There are limitations; for example, the success/failure dichotomy must be an appropriate description of the operation of each element and of each group of elements in the system. This can be rather restrictive. There are also some difficulties in complex systems of finding all the paths through the system. ##

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Serial Number 2064
ASQC Code 833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Switching devices

AUTHOR: Arthur Siegel, Staff Columnist, Defense Electronic Products Division, Radio Corporation of America, Camden, New Jersey

SOURCE: Electromechanical Design, vol. 9, February, 1965, pp. 18-19

PURPOSE: To discuss the problems of proving reliability for switches, and to suggest screening tests for that purpose.

ABSTRACT: Switches are used in small quantities and so it is difficult if not impossible to prove high quality by a statistical test which assumes no a priori knowledge. Screening tests could be developed for application to devices which had already been approved. This approval for device type would be conventional--qualification, environmental tests, etc. Each switch would have its characteristics measured before and after the screening tests. Limits for change could be established for each switch type and these would form the basis for an accept-reject criterion. The program will require the cooperation of many individuals, producers, and users. It will be expensive and time consuming. But what other way is there?

REVIEW: The arguments are good for trying to find a suitable screening test for switches whose basic design is acceptable. Some of the peripheral discussion, such as the usual proper application of nonmechanical parts, the fact that they are normally single function, and the discussion on the statistics involved in reliability fall somewhat wide of the mark.

Once the arguments for screening are accepted in principle, then the hard work and expense of translating them into hardware specs begins.

This regular column, while not dealing with reliability per se, does treat well those details which are so essential to high reliability. ##

Serial Number 2065
ASQC Codes 770;782;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Thermal-stress analyses of aerospace wires--accelerated "cut through" life tests

AUTHOR: (Editorial matter based on the paper "Thermal-Stress Analyses of Aerospace Wires" presented at the Bureau of Naval Weapons Symposium on Advanced Techniques for Naval Aircraft Electrical Systems, 13-14 October 1964 by F. J. Campbell and C. L. Baggett of the Insulation Section, Electromagnetic Materials Branch, Solid State Division, U. S. Naval Research Laboratory, Washington, D. C.)

SOURCE: Electromechanical Design, vol. 9, May, 1965, pp. 76-77

PURPOSE: To discuss the application of a standard aging procedure for finding the life of aerospace wire insulation.

ABSTRACT: Degradation due to heat exposure is the predominant factor affecting life in most insulating materials in that it weakens their resistance to mechanical stress, penetrating moisture and electrical stress--which ultimately produce system failures.

Conductors, subjected to lateral pressure such as that caused by a sharp bend around a bulkhead, may be cut through the insulation thus causing a short circuit. In order to test various insulations under a cutting stress, a simulated test procedure bends an 18" length of unaged wire over a mandrel with a three-lb weight on each end of the specimen. A continuous 120 volts ac potential is applied between the conductor of the specimen and the mandrel while it is exposed to a constant oven temperature.

Another method for evaluating cut-through life tried in the Naval Research Laboratory applies the cut-through stress between two strands of the same wire by constructing a two-loop chain supporting a three-pound weight. The results from this method have not been definitely correlated with those from other methods yet, but it is a much quicker test. (Author in part)

REVIEW: This is a summary of the original paper mentioned in the text. The main aging test was described earlier in the paper covered by Abstract and Review Serial Number 1752. (When a few points are extrapolated a great distance, there is a tremendous uncertainty in the extrapolated values, even granting the form of the equation. A statistician should always be consulted in this circumstance.)

The aim of short effective life simulation tests is very good and the development of such tests should be encouraged. ##

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Serial Number 2066 -1
ASQC Codes 711;713;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A discussion on damage and failure mechanisms of heavy-section steel

AUTHORS: (Organized by L. Rotherham)

SOURCE: Proceedings of the Royal Society Series A Mathematical and Physical Sciences, vol. 285, 6 April 1965, pp. 3-140 (published by the Royal Society, Burlington House, Piccadilly, London, W. 1, England)

PURPOSE: To record the proceedings of a one-day discussion meeting on damage and failure mechanisms of heavy-section steel.

ABSTRACT: There are ten papers in this issue. Two are introductory, four are theoretical and four report experimental results. All except the first deal with the physics of failure. The titles and abstracts are given below.

Failure of steel structures: causes and remedies, by R. Weck, British Welding Research Association, pp. 3-9.
There are six basic mechanisms of failure: failure due to excessive plastic deformation as the result of static overload or impact, instability, creep, stress corrosion, fatigue and brittle fracture. Conventional design methods almost entirely eliminate the risk from the first two causes, and to a very large extent the risk of failure from creep. Fatigue is the most common cause of failure, and brittle fracture the most spectacular. In the occurrences of failure, joints and in particular the presence of welded joints, frequently play a decisive part owing to: (a) the stress concentration they produce, (b) the residual stress caused by welding, and (c) the metallurgical changes produced by welding. The remedy for avoiding these failures lies in two directions: the wider spread of what is already known mainly through normal educational channels, and an intensification of the research effort in those areas where knowledge is still fragmentary.

Mechanics of fracture in large structures, by A. H. Cottrell, Metallurgy Department, University of Cambridge, pp. 10-21.
A dislocation theory of cracks, which takes account of elastic-plastic and other non-linear modes of deformation, is used to discuss the geometrical and physical conditions for unstable fracture. The importance of discontinuous cracking in providing an unstable mode of plane strain, semi-brittle, tensile fracture is emphasized. The general formulae reduce to those of Griffith, Orowan, and Irwin, at low stresses. Size effects and their relation to microscopic processes of deformation and fracture, especially twinning, are discussed and the concept of the crack arrest temperature is considered.

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65A21973 Representation of plasticity at notches by linear dislocation arrays, by B. A. Bilby and K. H. Swinden, Department of Metallurgy, University of Sheffield, pp. 22-33.
Further work is reported on the use of linear dislocation arrays to represent plastic relaxation round notches. In previous papers the relaxation in an infinite medium by arrays collinear with the notch was treated, both for a single notch and for an infinite sequence of notches. In the application of this work to the fracture of large structures the fracture criterion involves the achievement of a critical displacement at the notch root. The critical displacement has now been related explicitly to the applied stress, the yield stress, the notch size, the size of the structure and the extent of the relaxation, so that predictions about the dangerous stresses for a given notched structure, and the dangerous notch sizes for a structure subjected to a given stress can be obtained.

65A21974 The application of fracture mechanics to yielding materials, by A. A. Wells, British Welding Research Association, pp. 34-45.
The paper begins with a restatement of the ideas underlying the choice of a hypothesis of crack opening displacement for brittle fracture initiation, where sharply notched bodies of materials with well-defined yielding properties are subject to fracture either below or at general yield. It is maintained that a displacement is preferred to a strain criterion in order to encompass fracture size effects. Slow notched bend and tension tests conducted at various temperatures on 3 in. thick, mild steel plates are described, in association with autographic measurements of crack opening displacement at fracture. The latter criterion for fracture initiation is found to be largely vindicated by test results. Minor departures from constancy of fracture displacement at given temperatures are examined in relation to variations of notch root triaxial stress intensification with the different specimen shapes and loading conditions.

4 Strain concentration effects in large structures, by E. Smith, Central Electricity Research Laboratories, Leatherhead, Surrey, pp. 46-67.
When a large structure is subject to a temperature lower than the crack-arrest temperature of the particular steel from which it is built, the problem of fracture initiation at stress concentrations becomes of paramount importance. On the basis of the attainment of a critical local displacement as the criterion for fracture initiation, a theoretical analysis has been undertaken on some aspects of the fracture of large sections. In particular a simple calculation has been made for the fracture stress of a large plate containing a notch; the results are identical for small stresses with those given by the fracture mechanics (energetic) approach.

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Serial Number 2066 -3
ASQC Codes 711;713;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

65A21975

Effects of root radius, stress, crack growth and rate on fracture instability, by F. A. McClintock, Massachusetts Institute of Technology, pp. 58-72.
Of various criteria for fracture at the root of a notch, the energy, local stress, and displacement criteria have limited validity. More appropriate is the history of both stress and strain over a small region ahead of the crack, as required for fracture by the coalescence of holes. Expressions are given for crack initiation, growth, and subsequent instability in antiplane strain of a non-hardening material. Instability is shown to depend primarily on those strain increments arising from crack growth at constant load rather than on those from increasing load at constant crack length. Thus final instability conditions are similar for single and double-ended cracks, round notches, and cracks cut under constant load. Round notches may give instability, restabilization, and final instability. The growth and coalescence of holes in front of a crack in a linearly viscous material is studied for both tensile and anti-plane-strain cracks. The absence of residual strain eliminates instability, but the crack continually accelerates.

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The distribution of strain about a running crack, by P. L. Pratt and T. A. C. Stock, Imperial College, London, pp. 73-82.
In semi-brittle fractures in heavy-section mild-steel structures the propagating crack is accompanied by a moving field of elastic-plastic deformation. This field determines the effective value of the surface energy. Its nature can vary with the conditions of testing and may be related to the properties of the material itself by means of dislocation dynamics. It is difficult to calculate this field; thus experimental measurements of the distribution of strain around running cracks are given.

G

Brittle behaviour in laboratory-scale mechanical testing, by D. E. W. Stone and C. E. Turner, Mechanical Engineering Department, Imperial College, London, pp. 83-103.
Instrumented tests on various geometrically similar sizes of test pieces in notch tension, bending and impact notch bending are described for two grades of mild steel. Data on variation of the ductile-brittle transition with size, stress state and strain rate are presented. The decrease in size in slow notch bending can decrease the 50% crystalline transition temperature by 100°C. Agreement between, say V notch Charpy impact and 3 in. notch tension data appears to be largely fortuitous. At low temperatures maximum loads pass from well above to gross yield loads or less. There is no direct relation between the normally observed appearance or energy transition temperature and this much lower temperature load transition.

Fast and brittle fracture studies related to steel pressure

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

vessels, by R. W. Nichols, United Kingdom Atomic Energy Authority, Culcheth, Lancs., pp. 104-119.
Work aimed at the assessment of failure mechanisms in steel pressure vessels has included bursting tests on 5 ft. diameter cylinders containing longitudinal slits of varying lengths. Catastrophic failure resulted from partially pneumatic pressurization to hoop stress levels below those for general yield with slits of 12 in. overall length or greater. For a given slit length there was only a small variation of failure stress with variation of temperature through the transition range. Tests on different steels indicated that the failure strength is dependent on the yield strength and Charpy energy values at the test temperature. Mechanisms which could lead to the dangerous long defects include fatigue and brittle fracture. Crack-arrest tests on specimens up to 5 in. thick and 7 ft. long have shown that the isothermal temperature can be considerably higher than the gradient 'shear lip' temperature, and that the isothermal arrest temperature increases with specimen thickness even with the material of constant metallurgical quality.

Metallurgical and size effects in notched-bend tests, by N. P. Allen, C. C. Earley and J. H. Rendall, National Physical Laboratory, pp. 120-140.
Tensile and slow notch-bend tests carried out on 1.5% Mn-Mo steel with 0.002% and 0.054% P and to a number of different tensile levels showed that: (1) as the tensile proof stress of the steels was increased above 70 tsi, the fracture load in notched bending decreased, (2) this fracture load was dependent on the proof stress; tempering temperature of the steel and testing temperature seemed to be important only in that they alter the proof stress, and (3) increases in the size of the bend test specimen or of P content decreased the nominal fracture stress in bend at any given tensile proof stress when the proof stress was above about 80 tsi. A calculation, allowing for plastic relaxation, of the maximum tensile stress beneath the notch at fracture has been made and the relation between this stress and the nominal fracture stress has been discussed.

REVIEW: The first paper is an especially good easy-to-read introduction to the failure of steel structures. All designers should be familiar with its contents. The other papers deal more with the physics of failure, especially fracture mechanics, and will be of interest to workers in that field. Some useful additional information is found in the discussion which is presented on pp. 141-174 in the same issue. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Hints and kinks

AUTHOR: Paul Gottfried, Booz-Allen Applied Research, Inc., Bethesda, Maryland

SOURCE: IEEE Reliability Group Newsletter, vol. 11, issue 2, April, 1965, p. 3

PURPOSE: To provide a helpful essay on an important reliability topic--the stress-strength model of failure.

ABSTRACT: Among the undying and fadeproof ideas in reliability, we find the concepts expounded by Robert Lusser in the 1950's. Lusser was instrumental in promoting general awareness of the "reliability problem" and the need to do something about it; his ideas stimulated heated and highly audible controversy in public and private. Much of this controversy centered on test-to-failure methodology, with application of the Normal distribution to stress-strength theory. In its early forms, stress-strength theory was based on the assumption that both device strength and operating stress are Normally distributed. The approach originally involved setting a "reliability boundary" at a stress six standard deviations from the mean stress, and requiring an appropriate safety margin--typically five standard deviations--between the mean strength and the reliability boundary. The next step was to discard the reliability boundary and work directly with a diagram indicating the overlap of strength and stress distributions. For some time, the area of overlap was--erroneously--taken to be the measure of unreliability..

Most recently, recognition has been given to the fact that the distributions of interest often are non-Normal. Hopefully, this is only the beginning of a wider appreciation that extreme values and mavericks are of greatest significance where very high reliability objectives are involved. Of course, the need to estimate the relative frequency of such relatively rare events leads right back to one of the fundamental problems in reliability--the extreme difficulty in getting adequate data. All in all, it must be conceded that stress-strength concepts have helped in achieving substantial reliability improvements over the years, despite errors in formulation and application. To make reliability statements involving a long string of nines to the right of the decimal point on the basis of these models, on the other hand, is arrant nonsense or worse. (Author in part--virtually entire article)

REVIEW: This is an excellent short piece on the problems of the stress-strength model of failure. It supplements an earlier excellent piece by the same author in this Newsletter (see Abstract and Review Serial Number 1739). ##

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Serial Number 2068
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Tin-nickel alloy plating does not grow whiskers in five years

AUTHOR: --

SOURCE: IEEE Component Parts Group Newsletter issue no. 26, December, 1964, p. 5 (reprinted from the 1964, No. 64, Issue of "Tin and Its Uses," issued by the Tin Research Institute, Greenford, Middlesex, England)

PURPOSE: To report that tin-nickel alloys do not have whisker growth.

ABSTRACT: Inspection of the tin-nickel specimens at intervals has confirmed that no whiskers have appeared after five years. In addition, we have examined the variety of tin-nickel-plated objects that are available to us in our laboratories and offices at Perivale, whether exposed, under cover, or stored in cupboards and we find that none have developed whiskers.

Whatever the mechanism of whisker growth, it now appears that it is unlikely that such growth occurs spontaneously on tin-nickel. The immunity of tin-nickel to whiskers will certainly become a decisive influence in the design of any electronic equipment where it is essential to avoid the risk of whiskers bridging from one component to another. (Author in part)

REVIEW: This is a brief physics-of-failure report and may well be of interest to designers of relays, switches, printed circuit boards, etc. Of course many other materials do not have whisker growth. Silver is the most notorious of the whiskery metals. ##

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Serial Number 2069
ASQC Codes 814;815;816

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability costs and guarantees

AUTHOR: Robert A. Yereance, Program Director of Reliability, Battelle Memorial Institute, Columbus, Ohio

SOURCE: Systems Design, vol. 8, June, 1964, pp. 3-4

PURPOSE: To express some pessimism about the problems of guaranteeing reliability.

ABSTRACT: Reliability is usually associated with a cost of some sort whether measured in money, time, life, or whatever. The buyer always assumes the risk that he will not get what he asked for. If the buyer insists on guaranteed reliability (however it may be defined) he can still only get at most what he pays for or the vendor is a fool. We have many quality approaches that have been designed to alleviate the problem, but we have not succeeded too well where very high quality is concerned. Most of us pay lip service to the idea that quality/reliability begins very early in the programs, but few people act as if they believed it.

REVIEW: This essay sets a mood--which is pessimistic--and says things which need saying. The picture is not quite as black as presented, however, because there is more to the process of buying and building than is assumed here. ##

Serial Number 2070
ASQC Code 800

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability facts and factors--case histories in failure-cause detection

AUTHOR: Robert A. Yereance, Program Director of Reliability, Battelle Memorial Institute, Columbus, Ohio

SOURCE: Systems Design, vol. 8, August, 1964, pp. 4-5

PURPOSE: To show by examples that unreliability causes are ubiquitous.

ABSTRACT: Reliability requires infinite attention to detail, yet this attention is often lacking--partly because some other motives have a too high priority. Part type numbers may stay the same even though some component has been changed. If the number were changed, there would be too many complications..and really, the new one is better; so why worry? If the process is not behaving as expected, then the parts may have unexpected failure modes--even though all specified tests have been passed. Many times the equipment which is used to test an assembly will cause some damage to it. In one case a micrometer check was causing an unreasonably high pressure on the part. In another case a leak test was not sensitive enough to catch all slight defects; the test fluid then caused further damage to these wrongly accepted units. Lack of attention to detail--having a very strong chain except for one weak link--causes no end of trouble.

REVIEW: The problems presented here are mostly "people" rather than technical problems. Some engineers may say that therefore the problems are not important to them. But, on the contrary, these problems are part of the very essence of engineering. Reliability cannot be improved when the vagaries of people are not taken into account. Glowing accounts of reliability organizations often fail to consider what someone does--as opposed to what he ought to do.

This column provides a service to the reliability field by constantly reminding us of our real problems. ##

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G

Serial Number 2071
ASQC Codes 835;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability facts and factors--integrated circuit reliability needs

AUTHORS: Jack L. Easterday and Robert A. Yereance, Battelle Memorial Institute, Columbus, Ohio

SOURCE: Systems Design, vol. 9, February, 1965, pp. 6-9

PURPOSE: To discuss the failure rate of integrated circuits.

ABSTRACT: Integrated circuits are more complex than ordinary components yet less complex than many functional units which are customarily treated as black boxes. The failure rates of integrated circuits are low and difficult to measure. In this growing field there are few standards for failure. We must do the best we can, however; failure rates from a Battelle survey are given in several tables and graphs. At room temperature, a 10^{-7}/hr failure rate is a good "ball-park" figure; at 100^{o}C, 10^{-6}/hr is a good figure. The storage tests show a log failure rate which is a linear function of the reciprocal of absolute temperature.

As many failure modes are eliminated, more basic study will be necessary to find the failure modes which are inherent in the process itself. These circuits are already no less reliable than those made from the best individual components.

REVIEW: This is a short survey article and is satisfactory as such. The mechanisms of failure are not explored in any detail. The implicit hope that workmanship mistakes will become negligible compared to inherent weaknesses may not be well founded and may be very difficult to check. ##

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Serial Number 2072
ASQC Code 433

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability facts and factors--Bayesian statistics

AUTHOR: Robert A. Yereance, Program Director of Reliability, Battelle Memorial Institute, Columbus, Ohio

SOURCE: Systems Design, vol. 9, April, 1965, pp. 6-7

PURPOSE: To discuss the use of prior information in predicting the outcome of Bernoulli trials.

ABSTRACT: The use of Bayesian estimation procedures, involving in particular Laplace's "Rule of Succession," is briefly discussed in a reliability context. In particular it is stated (in essence) that if a trial of N items of equipment results in r successes the probability of success in one further trial is (r+1)/(N+2). Combinations of Bayes estimators are also discussed.

REVIEW: Let p denote the probability of successful operation in a single trial. Then the basic underlying assumption is that p itself has a "prior distribution" which is uniform over [0,1]. That is, before any experiments are performed, p is assumed to be "equally likely to lie anywhere between 0 and 1." If this is accepted, then standard probability arguments lead to the results quoted in the paper.

It is clear that under such assumptions there are difficulties in interpreting the precise meaning of the reliability figures obtained. (This of course is also true for Bayesian arguments in general.) It is felt that the use of these arguments, such as the Laplace "Law of Succession" suggested will not give an ultimate solution to, for example, the problem of estimating reliability from tests with few or no failures. For instance suppose 100 tests yield 99 successes. Then the statements

(1) The (usual, unbiased) estimate of the probability of success is 99/100, and

(2) The (Bayesian sense) probability of success in the next trial is 100/102

are not really so very different.

However, the application of Bayesian methods is interesting and, as in other fields, it can lead to greater understanding of the problems involved. It should perhaps be noted that the (Bayesian) probability of success in the next trial is not identical to the <u>estimate</u> of the success probability p. ##

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Serial Number 2073
ASQC Codes 815;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Approaches to reliability

AUTHOR: (Part of "Designing for Space," An Electronic Design Special Report by Ralph Dobriner, News Editor)

SOURCE: Electronic Design, vol. 12, July 20, 1964, pp. 50-55

PURPOSE: To summarize some of NASA's general approaches to reliability.

ABSTRACT: Some of the key ingredients for reliability are:

1. Specifications of design goals.
2. Assessment of design reliability.
3. Review and documentation of systems design.
4. Specifications of preferred parts and materials.
5. Specification of preferred practices.
6. Establishment of a testing program.
7. Establishment of a failure feedback and analysis program.

The PRINCE system is used to accumulate reliability information on components from all sources. A reliability program is essential and the one used at Goddard is cited as an example. Minimum reliability goals are set and the design is reviewed at appropriate milestones. Care is taken with all documents and drawings; preferred materials, practices, and components are specified where possible. Standards are set for workmanship where feasible. There is a complete testing program for engineering, performance, environmental and life tests of the system and subsystems. Prototype models are subjected to stress levels significantly higher than those normally expected. There are formal design qualification and flight acceptance programs. Failures are reported, analyzed and the corrective action initiated. A detailed history of each space system is kept for reference. Environmental testing and analysis is extensive. (Author in part)

REVIEW: This is a general article and does not go into any subject very intensively. The Merit Index program probably is not as active as is implied. The PRINCE program will give a lot of raw data, but no neat, concise summaries; thus it is not too easy to use. Some of the failure rates are listed to four significant figures; this is very misleading and may even cause self-deception. At best, failure rates are probably good only within a factor of 1.5.
##

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Serial Number 2074 -1
ASQC Codes 801;830;851

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability: Step by step help for the non-expert
An Electronic Design Special Report
Robert H. Cushman, Technical Editor

G

SUBTITLES AND AUTHORS:
Step 1. Trouble spots in circuits--can you find them?
Nathan O. Sokal, Di/An Controls, Inc., Boston

Step 2. Reliability terminology--do you understand the most basic terms?
(adapted from an article by William B. Rossnagel, Aerospace Division, Walter Kidde & Company, Inc., Belleville, New Jersey)

Step 3. Know when to stop testing
Gene T. Gaddis, Aeronautical Division, Honeywell, Inc., Minneapolis

Step 4. Learn from other designers
Paul T. Knesel, Military Electronics Division, Motorola, Inc., Scottsdale, Arizona

SOURCE: Electronic Design, vol. 12, November 9, 1964, pp. 31-52 (Step 1: pp. 32-37, Step 2: pp. 38-43, Step 3: pp. 44-49, Step 4: pp. 50-52)
A correction pertaining to Step 2 is found on p. 17 of the December 7, 1964 issue of Electronic Design.

PURPOSE: To describe four steps which the average engineer can take to improve the reliability of systems.

ABSTRACT: Step 1. Perform the basic circuit design task more thoroughly. Ten circuit design examples are given, in each of which a weak spot occurs. The reader is asked to detect the weak spot. Answers are given.

Step 2. Understand what the most basic reliability terms mean. This paper presents an informal look at the meanings of the terms "MTBF" and "average life" in an example based on the automobile tire. If the familiar "bathtub" curve of failure rate vs. time pertains, then MTBF is the mean time between failures during the central (flat) portion only. Average life is the mean time to wearout failure over the right-hand end portion. The correction (see SOURCE) states that in adapting this article from the author's manuscript, ED omitted a key sentence which said that the MTBF calculations on p. 40 were based on two sets of tires.

Step 3. Set up tests to predict accurately and quickly whether the system meets its contract MTBF. If the true MTBF of a system is greater than the specified MTBF, there is a much better chance of passing a life test. The greater the ratio (true MTBF/specified MTBF), the shorter the test time can be. Graphs

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

are provided for making the calculations. Naturally the shortest test time with a reasonable chance of passing is desired.

Step 4. Learn by studying successful designs. A command receiver with a reliability of 0.95 for one year is shown as an example.

REVIEW: This is a series of four separate articles, each designed to illustrate a particular point. It is in no sense a comprehensive guide to reliability.

Step 1 is perhaps the most interesting since it deals with examples of trouble spots. It will take great familiarity with the particular circuits to easily see the trouble, but the answers provide help for the non-specialist.

Step 2 on terminology is satisfactory for a rough understanding, but some of the definitions lack rigor that could be important. No distinction is made in the text between hazard rate and failure rate although an attempt is made to show the difference on the curves of Figure 1. The failures are random in all portions of the curve, not just the useful period (a further discussion of this point is given in Review Serial Number 1216). It is also obvious that if the shape of the curve were not predicted in advance, one would never guess it from the data. The footnote on p. 40 is in error; 3σ limits for a normal (Gaussian) distribution do not correspond to 1%. No mention is made of the Poisson distribution of actual number of failures when the expected number is given. The assumption of statistical independence of failures is blithely made and could easily be violated under certain road conditions.

Step 3 on testing time is somewhat difficult to follow. The author, in a private communication, has indicated that the magazine editor, in his attempt to meet space limitations, inadvertently deleted critical information from the master document. As a result of this, there are several omissions or misleading statements:

(a) In Figure 1 for probability of passing the test, the whole figure is not for the 80% Lower Confidence Level (LCL) on true MTBF, but only the brown dashed lines.

(b) Figures 2 and 3 for probability of passing the test do not contain the test time. For Figure 2 the 80% LCL is not mentioned on the figure. The test time is a function of contract MTBF, the number of failures allowed, and the LCL. In general

$$1 - LCL = Q[(2T/M_c) | 2c' + 2],$$

where $Q[\chi^2 | \upsilon]$ is the cumulative (from the right) χ^2 integral for υ degrees of freedom and c' is the maximum number of failures

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allowed. For c' rather large, $T/M_c \approx \sqrt{c'} + c'$ and is independent of the LCL within a reasonable range.

(c) In cases where the random variable is discrete and where a true value is being estimated by an interval, the confidence statements are of the form: "the confidence is greater than..." or "the confidence is less than...." The exact confidence is not known.

(d) The designation of the ordinate on the enlarged portion of Figure 3 should read "... in %", not "...10%."

Other than the above, this section can be helpful. Of course the assumption of constant failure rate (more properly, constant hazard rate) is implied in the entire discussion. The test time T is the total for all equipments--it makes no difference how many there are.

This analysis brings to mind a defect in our whole testing system: The manufacturer "knows" his system has an MTBF (say) 1.5 times the contract MTBF, yet the tests he must run are based on the assumption that he knows absolutely nothing about his product. As yet, there seems to be no quantitative way of taking this engineering knowledge into account.

Step 4 was intended to "stress the significance of using low-level (component and function level) redundancy to increase reliability .... A close look at the schematics will reveal that low-level redundancy has been incorporated in many different types of circuits..." as indicated by the author in a private communication. Due, apparently, to heavy editing, the message does not come through very easily.

In summary, these articles just give a series of isolated glimpses into what reliability is all about. ##

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64 N 27220.

Serial Number 2075 -1
ASQC Code 090

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Bibliography on reliability

AUTHOR: Harold S. Sharp, Engineering Information Analyst, Lockheed-Georgia Company, Marietta, Georgia

SOURCE: 25 pp., Lockheed-Georgia Company, Scientific and Technical Information Department, Marietta, Georgia, June, 1964 (NASA accession number N64-27220; DDC AD No. 603266)

PURPOSE: To present a bibliography on reliability covering the period 1957 to 1963.

ABSTRACT: This bibliography is a survey of representative articles in the literature of reliability. It is by no means exhaustive.

Coverage is from 1957 to 1963, inclusive. No attempt was made to list material prior to 1957 since an excellent bibliography covering many of the available references to that date has already been compiled (Reference is cited in the bibliography).

Most of the references cited have been gleaned from Engineering Index, while additional papers and references have been taken from such reports as the Proceedings of the National Symposia on Reliability and Quality Control in Electronics (1957-1960); Electronics Reliability in Military Appliances, General Report No. 2, July 1957; the Aeronautical Electronics 1958 National Conference Proceedings; and from a few miscellaneous sources.

The references are arranged under the following headings:

Reliability--General
Aerodynamics
Air Navigation
Aircraft
Automatic Control
Aviation
Computers
Education
Electric Circuits
Electric Relays
Electron Tubes
Electronic Equipment
Equipment
Human Engineering
Information Theory
Maintainability
Management
Mathematical Theory
Missiles--Control
Missiles--Electric Equipment
Missiles--Launching
Missiles--Manufacturing
Missiles--Reliability
Missiles--Simulators
Missiles--Testing
Optimum Network Synthesis
Product Design
Quality Control
Rockets and Rocket Propulsion
Semiconductors
Telemetering
Transistors
Vibrations
Voltage Regulators
Voltmeters

(Author in part)

REVIEW: Although the stated period of coverage of this bibliography is

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

1957 to 1963, the bulk of the references are dated prior to 1960 (some prior to 1957). Thus a good deal of more recent information exists on many of the above topics. Those who are making literature searches in these areas will find it useful to scan this listing, but they should not rely on it as containing reference to the latest information. An additional difficulty is the fact that the selection of headings is far from optimum for information-retrieval purposes. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A British approach to reliability

AUTHOR: A. H. Cooper, Technical Director, EMI Electronics Ltd.

SOURCE: Electronic Components, vol. 4, pp. 717-721, July, 1963

PURPOSE: To present a realistic look at the challenges and pitfalls of high reliability.

ABSTRACT: Although, of course, the proportions vary from one electronic equipment to another, one can divide the causes of failures into four groups: failures of components which are being used within their ratings; failures of components precipitated by their being used outside their ratings; failure of mechanical parts; and failure of the equipment due to operator error. On a wide average, these four groups are of roughly the same size.

Obviously, one must attack all four areas at once if any real progress is to be made. This means that one can decry the overinsistence on hi-rel parts when there is no associated insistence on good design, etc. On the other hand, one can properly complain about the absence of the same parts. Good design is difficult but not impossible and the best of us make silly mistakes sometimes. It is very difficult to predict exact component temperatures during the design stages and small increases over the design value can be very detrimental. Much hardware is poorly designed so that it causes failure of otherwise well-designed equipment. Field reporting of failures is generally in sad shape, exceeded in sadness only by the way some people pay no attention to the reports which they do get. (Author in part)

REVIEW: As the magazine editor comments "It is, in our view, one of the most down-to-earth articles yet written on reliability and we earnestly commend it to the careful attention of all our readers." There is humor combined with a depth of understanding of the problems of creating good hardware. The article takes little time to read--time which will be well spent. ##

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ASQC Code 800

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability: some aspects, principles, precautions and experience

AUTHOR: Paul Dietrich, German Correspondent, Electronic Components

SOURCE: Electronic Components, vol. 4, pp. 1194-1198, December 1963

PURPOSE: To report on a reliability conference held in Nuremberg, Germany in May 1963.

ABSTRACT: Twelve papers are summarized:

1. E. G. D. Paterson: One can predict reliability of equipment by testing or by calculating it from the reliability of parts, whichever is more convenient. The development and production of the equipment must be done carefully, thoroughly, and properly.

2. F. Baumgartner: In order to make high-reliability military equipment one must carefully inspect all incoming materials; circuits must be designed with adequate tolerances which are neither too tight nor too loose; the equipment must operate in extreme environments, especially in high and low temperatures; it should have a long shelf life and be easily serviced by ordinary maintenance people. In the past, electronics failures predominated; now it is mechanical failures.

3. M. Klimek: Many people pay only lip service to reliability; they are not willing to pay the extra price for it. They are only too willing to accept merchandising instead of reliability. Automation and developments such as printed circuits have considerably decreased the number of failures.

4. F. Koppehele: Redundancy can improve the reliability of equipment. It can be either standby or continuous. The equipment should be first designed to have as long life as possible, then redundancy should be added at the proper level.

5. E. Rusch spoke on life distributions.

6. H. G. Kleedehn: The failure rate (more properly the hazard function) follows the "bath tub" curve as a function of time.

7. G. Schütt: The reliability of radio relay links can be analyzed in many ways. Failures are classified as to length of time, type of cause, component that failed, etc.

8. A. Esprester: Approximate failure rates are: transistors, 10^{-4}/1000 hr; diodes, 2×10^{-5}/1000 hr; resistors and capacitors, 10^{-6}/1000 hr.

9. E. Schlaf: Nuvistors are a big improvement in reliable tubes due to the materials and methods of construction.

10. G. Helwig: Rectifiers have been vastly improved. In particular, the advances in selenium rectifiers are given.

11. F. Beyerlein: The acceleration factors for capacitors at high voltages and temperatures are not constant. On particular capacitors the voltage exponent can run from "over five" at

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

operating voltage up to 12 at high voltages.

12. H. W. Hagmeister: Failure rates of transistors on test are given. They are worse than those actually experienced in operating equipment.

REVIEW: While the conference may well have been a help to the people who attended it, the technical content of the summaries in this article has little to offer the American reader. (The same comment could, of course, be made about many symposia held both at home and abroad.) There is no mention of a proceedings or of author addresses. ##

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64N26246

Serial Number 2078 -1
ASQC Codes 833;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Alkaline battery evaluation

AUTHORS: W. W. Clark, W. G. Ingling, I. F. Luke, and E. A. Roeger, Jr., Inland Testing Laboratories, Cook Electric Company, Dayton, Ohio

SOURCE: Technical Documentary Report No. APL TDR 64-76, 293 pp., June 1964, A. F. Aero Propulsion Laboratory, Research and Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, Project No. 8173, Task No. 817304. (NASA accession number N64-26246; DDC AD No. 602676)

PURPOSE: To establish a broad base of battery test data for use in the design of the electrical systems of future space vehicles and to determine the actual failure mechanism of new battery systems under varying environmental and cycle-life conditions.

ABSTRACT: This report covers an alkaline battery applied research and failure analysis program which includes the cycle-life performance evaluation and failure analysis of the following types of sealed secondary alkaline cells: one type of 12-ampere-hour nickel-cadmium cells; one type of 20-ampere-hour silver-cadmium cells; and one type of 25-ampere-hour silver-zinc cells. It includes the final results of cycle-life performance tests on 240 12-ampere-hour nickel-cadmium cells in groups of 10 cells and batteries of 20 cells, and 150 20-ampere-hour nickel-cadmium cells in groups of 10 cells. The 12-ampere-hour cells were cycled in four temperature environments with four depths of discharge in each environment, while the 20-ampere-hour cells were cycled in five temperature environments with three depths of discharge in each environment. All cell groups and batteries were cycled in 90-minute periods consisting of 55 minutes of charge and 35 minutes of discharge. Also included in this report are the results of cycle-life performance tests conducted on 192 25-ampere-hour silver-zinc cells and 192 20-ampere-hour silver-cadmium cells separated into eight cell groups. Both types of cells were cycled in four temperature environments with three depths of discharge in each environment. One half of both types of cells was cycled in two-hour periods consisting of 85 minutes of charge and 35 minutes of discharge, while the other half was cycled in 24-hour periods consisting of 22 hours and 48 minutes of charge and 72 minutes of discharge.

The cycle life of the 12-ampere-hour nickel-cadmium cell is inversely related to the per cent discharge with the greatest cycle life at each depth of discharge at an ambient temperature of 75°F. Results indicate that these cells would be unsatisfactory for operation with prolonged ambient temperatures below 0°F. The cycle life of the 20-ampere-hour cell is inversely related to the depth of discharge with little regard to cell temperature. The

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

cycle life of the 25-ampere-hour silver-zinc cell is very poor for depths of discharge of 50 per cent for the two-hour cycle period and 75 per cent for the 24-hour cycle period regardless of cell temperature. The cycle life of the 15-ampere-hour silver-cadmium cell is also inversely related to the depth of discharge for both cycle periods with little regard to temperature variance.

REVIEW: This is a very long and detailed report of test data on battery and cell groups. Hundreds of performance curves are presented together with a detailed statement of test methods. In view of the vast amount of data presented, the summarizing conclusions section is perhaps a bit weak and more effort is required to find pertinent results than should be necessary. In a comparison of single nickel-cadmium 12-ampere-hour cell performance (in cell groups) with the corresponding 20-cell battery, performance is of little validity since polypropylene separators were used in the cells in the batteries while cellulose separators were used in the cells in the cell groups. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Non-destructive testing--A report bibliography

AUTHOR: (compiled by Elizabethe H. Hall, DDC)

SOURCE: DDC AD No. 421564, November, 1963

PURPOSE: To present a list of the references on the subject of non-destructive testing which have been catalogued by DDC from 1953 through September 1963.

ABSTRACT: About 500 DDC documents are referenced under the headings:

- Methods, techniques, and their applications
  - Acoustics (sonic and ultrasonic)
  - Electric and electrostatic
  - Electromagnetic induction
  - Magnetic
  - Neutron
  - Penetration
  - Pressure and leak testing
  - Radiography (gamma and X rays)
  - Thermal
- Bibliographies, conferences, and symposia
- General
- Miscellaneous

REVIEW: This should prove useful to those doing an intensive search on some phase of non-destructive testing. The number of useful documents is probably less than 300 since many monthly progress reports are catalogued in this bibliography. Some documents are dated well before 1953. There certainly is not complete coverage of any particular field either--only a list of the DDC documents. ##

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G

Serial Number 2080
ASQC Codes 770;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Major causes of product failure and their prevention

AUTHOR: I. J. Fuchs, Director of Engineering, United States Testing Company, Inc., Hoboken, New Jersey

SOURCE: 4 pp., presented at the ASME Design Engineering Conference, New York, New York, May, 1963, Paper No. 63-MD-21

PURPOSE: To give illustrations of product failures and to suggest adequate testing as a means of prevention.

ABSTRACT: Five major causes of product failure are explored; misapplication of product, poor mechanical design, inadequate control of materials, poorly controlled manufacturing techniques, and misapplication of materials. The use of laboratory and field testing is offered and discussed as a tool available to the design engineer as a prevention for product calamities. One example is given for each case. (Author in part)

REVIEW: Other than the examples, the essence of the paper is given in the above ABSTRACT. Adequate testing is important and the author's position is understandable in view of the type of work his company does. ##

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Serial Number 2081
ASQC Codes 815;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Avoiding electrical failures caused by mechanical operation

AUTHOR: W. A. Farquhar, Electrical Engineer, Underwriters Laboratories, Inc., New York, New York

SOURCE: 4 pp., presented at the ASME Design Engineering Conference, New York, New York, May, 1963, Paper No. 63-MD-26

PURPOSE: To discuss electrical failures with respect to the Underwriters' Laboratories activities.

ABSTRACT: Electrical failures that can be attributed to mechanical operation of an appliance or tool may result from either normal use of the product or from its misue or abuse. Both causes of potential electrical failure must be considered when establishing product safety standards, for it is almost a complete certainty that if a product can be abused, it will be.

Electrical failures that result from normal use of the appliance will, in general, be due to one or more of the following:

(a) Vibration, producing conductor breakage or insulation breakdown.

(b) Mechanical motion, involving flexing of wiring and producing conductor breakage or insulation breakdown.

(c) Involvement of the power supply cord or of internal wiring with moving parts, producing conductor breakage or insulation breakdown.

(d) Solenoids blocked because of misalignment of parts, producing burnout of circuit components.

(e) Wear of moving electrical contacts due to misalignment, improper lubrication, selection of a contact material improper for the purpose, and so on, causing early switch or contactor failure.

(f) Excessively high acceleration or too frequent starts or reversals of motors, causing damage to motor armatures or commutators.

Electrical failures that result from the misuse or abuse of the product are probably more frequently caused by motor burnout, due to prolonged overloading, than by any other single cause.

Some of these causes of electrical failure can be eliminated with a fair degree of certainty, or at least can be reduced to an acceptable degree, by good product design. (Author)

REVIEW: This is a short general article and deals largely with the activities of the Underwriters' Laboratories in ensuring product safety. ##

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Serial Number 2082
ASQC Codes 832;836;837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability application to appliance engineering

AUTHOR: Gerald B. Cohen, Sylvania Electronic Systems-Central, A Division of Sylvania Electric Products, Williamsville 21, New York

SOURCE: 11 pp., presented at the 14th Annual Appliance Technical Conference in Chicago, Illinois, May 14 and 15, 1963, IEEE Conference Paper No. CPA 63-5030

PURPOSE: To chat about reliability engineering in consumer industries.

ABSTRACT: A design should be evaluated under the worst conditions of envisioned use. For this purpose, mathematical models are very helpful. It is a good idea to provide safety margins in the design. Human engineering is important both for safety and for ease of use. Designs should be reviewed before they go into production. Engineers should get a refresher course in the fundamentals of reliability. Failure analysis is important and should be fed back to design groups.

The United States Department of Agriculture Report on How Long Appliances Should Last gives this information: refrigerators: 16 years, electric washing machines: 11 years, dryers: 14 years, electric sewing machines: 24 years, automatic toasters: 15 years, vacuum cleaners:...uprights: 18 years, tank models: 15 years, freezers: 15 years, and T. V. sets: 11 years.

REVIEW: This reads as if the oral presentation were good and entertaining, and probably conveyed a number of useful ideas. As written material without the presentation it would seem to be of marginal value to the reader.

The author, in a private communication, has indicated that he will supply additional information on the subject upon request.
##

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Serial Number 2083
ASQC Code 821

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Errors in reliability prediction caused by the statistical relation between component failures

AUTHOR: Yu. G. Pollyak

SOURCE: Telecommunications and Radio Engineering, Part I, April, 1963, pp. 1-8 (published monthly by IEEE, Box A, Lenox Hill Station, New York, New York 10021)

PURPOSE: To show that an incorrect statistical independence assumption leads to errors in calculating reliability.

ABSTRACT: If statistical independence is incorrectly assumed in reliability calculations, the results are in error. With a positive correlation between component failures the calculated value of the reliability of series-connected components is lower than the actual value, and for parallel-connected components the calculated value is higher than the actual. In practice the correlation between component failures caused by random changes in operating conditions is always positive. A numerical example of the calculation of the error is given. (Author in part)

REVIEW: The point of the paper is quite correct. The author's phrasing of his comments on when the accepted formulas are correct is poor. Obviously the "accepted" formulas are not always accepted as being correct. By "accepted" he apparently means "assuming statistical independence." ##

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64N14387

Serial Number 2084
ASQC Code 800

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Life plus reliability

AUTHORS: A. Pugachev and N. Domotenko

SOURCE: Grazhdanskaya Aviatsiya, (Russian), Vol. 20, Nr. 4, 1963, pp. 16-17, Translation prepared by Translation Division, Foreign Technology Division, WP-AFB, Ohio, FTD-MT-63-108, October 25, 1963 (NASA accession number N64-14387)

PURPOSE: To discuss the reliability of the AI-20 jet engine.

ABSTRACT: The AI-20 jet engine has had its life increased by a factor of three. The biggest problem is uneven temperature distribution on the walls of the combustion chamber.

REVIEW: The above ABSTRACT contains the essential point of the article. The paper itself is not worth reading. ##

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7/65

Serial Number 2085
ASQC Codes 431;821

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability evaluation of automated electric systems

AUTHOR: A. I. Ressin (Riga)

SOURCE: Automation and Remote Control (A translation of Avtomatika i Telemekhanika, a publication of the Academy of Sciences of the USSR), vol. 24, pp. 208-216, September, 1963 (Instrument Society of America, 530 William Penn Place, Pittsburgh 19, Pennsylvania)
but see 63A14087, 66 N83571

PURPOSE: To analyze drift, catastrophic, and stochastic failures of a system.

ABSTRACT: For catastrophic failures the probability of no failure is shown to be $R(t) = \exp(-\int_0^t h\,dt)$ where h is the hazard function. When the changes in components occur very slowly, a different type of expression is used. Its exact form depends on the assumptions made. In some cases the inputs or the behavior of the system is stochastic in nature and the error in the output may randomly exceed prescribed limits. This problem can be reduced to the familiar zero-crossing problem and is so handled in the paper. An example is given.

REVIEW: Although the text reads somewhat roughly due to non-excellent translation, the points are well made. The mathematics was not all checked, but appears to be of good quality. It will generally be more convenient to get this type of information from American texts and journals where similar work has been done. This is a mathematical paper and the results are not in a form suitable for direct and easy use by design engineers. ##

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Serial Number 2086
ASQC Codes 716;821

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: On the reliability of elements subject to aging

AUTHOR: V. B. Gogolevskii (Moscow)

SOURCE: Automation and Remote Control (A translation of Avtomatika i Telemekhanika, a publication of the Academy of Sciences of the USSR), vol. 24, pp. 354-362, October, 1963 (Instrument Society of America, 530 William Penn Place, Pittsburgh 19, Pennsylvania)
but see 63A16290

PURPOSE: To determine life characteristics in terms of operating conditions.

ABSTRACT: The following assumptions are made:

1. Lifetimes have a Gaussian distribution for given operating conditions.
2. The mean life at one set of conditions is proportional to the mean life at another set of conditions. The proportionality constant is a function only of operating conditions.
3. The linear cumulative damage theory applies.

Using these assumptions, some formulas are derived for the mean and standard deviation of life. An example is given.

REVIEW: This article is not very profound although it does indulge in some mathematics. The translation is somewhat difficult to read. This type of information is available in ordinary American literature; there is no need to strain over this translation. ##

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Serial Number 2087
ASQC Codes 821;838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability of passive redundancy circuits with permanently connected redundant elements in the case of redistribution of loads or voltages

AUTHOR: A. L. Raikin, (Moscow)

SOURCE: Automation and Remote Control (A translation of Avtomatika i Telemekhanika, a publication of the Academy of Sciences of the USSR), vol. 24, pp. 517-521, October, 1963 (Instrument Society of America, 530 William Penn Place, Pittsburgh 19, Pennsylvania)

PURPOSE: To derive some special redundancy formulas.

ABSTRACT: The present article is concerned with circuits consisting of n parallel- or series-connected identical elements which must be able to operate when the over-all load or voltage is uniformly distributed among the elements. If an element fails in operation, the remaining elements take over its load or voltage. The reliability formula for such a circuit is derived for specific dependences of the extent of damage on the load power or voltage. The above circuits are compared with an (n-1)-uple redundancy circuit where the elements are connected according to the substitution method. (Author)

REVIEW: This article is rather difficult to follow; it reads as if the translator were not familiar with the field. Some of the terms such as "extent of damage" are difficult to interpret. The theory of damage is apparently contained in the first set of equations, the origin of which is not at all obvious. The cases treated here do not appear to have been treated extensively in the English language literature, but it may be easier to derive this kind of result when needed than to decipher the exact meaning of the article. ##

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Serial Number 2088
ASQC Codes 821;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The reliability of information nets

AUTHORS: V. A. Zhozhikashvili and Yu. I. Shmukler, (Moscow)

SOURCE: Automation and Remote Control (A translation of Avtomatika i Telemekhanika, a publication of the Academy of Sciences of the USSR), vol. 24, pp. 758-763, December, 1963 (Instrument Society of America, 530 William Penn Place, Pittsburgh 19, Pennsylvania)

PURPOSE: To carry out a general investigation of the reliability of a model which is a first approximation to an information system with arbitrary point location.

ABSTRACT: Let a set of points be located arbitrarily at any distance from one another. All these points must be joined by lines into a system, such that every two points are joined by one line and such that there is no loop in the resultant system, i.e., so that there is only one path between any two points. One of the points of the system will be called the dispatcher's point (DP), the remainder will be called active points (AP). The conditions of operation of this system are the following:

(1) All the AP are equivalent in the informational sense, and each of them transmits its information to the DP, which in its turn sends information to each of the AP;

(2) when any line ceases to function, information is no longer transmitted through the following line, but the damage is not propagated to the previous line (this is true for a break in a line and for short circuits under certain conditions);

(3) the probability of failure of any line is independent of its length and is equal to $\underline{p}$.

The points are supposed to be absolutely reliable.

The reliability coefficient is defined as the mean fractional number of points still functioning after the stated length of time. A solution is given of this problem of the reliability of information nets with an arbitrary distribution of points. The dependence of the reliability of a system on the location of the DP (dispatcher's point) is considered. The reliability of a system with spare communication lines is studied. An optimal-standby problem is solved. (Authors in part)

REVIEW: This is an easily understood paper (unusual for a translation). While not all the mathematics was checked, it appears to be of high quality. This problem is of interest with regard to communications systems rather than equipment itself. ##

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64N10353

Serial Number 2089
ASQC Code 800

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Basic directions in reliability theory

AUTHORS: N. G. Bruyevich and V. Grabovetskiy, USSR

SOURCE: JPRS:21923, 19 November 1963, 11 pp., U. S. Department of Commerce, Office of Technical Services, Joint Publications Research Service (NASA accession number N64-10353)

PURPOSE: To give a general discussion of a few reliability problems.

ABSTRACT: It is necessary to account for drift failures in addition to catastrophic failures. To this end, mathematical models of the system are helpful. By suitable design, drift failures can be minimized. Testing for reliability is usually long and tedious. The tests tend to be destructive and may not be suitable for small production lots. High reliability and long service life are important. In fact, they are many times more important to the economy than high volume production without them. Redundancy is a means of improving reliability.

REVIEW: The essential content of this paper has appeared many times in the American literature. Except for idle curiosity, there is no point in reading this translation. ##

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Serial Number 2090
ASQC Codes 431;822

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Limiting law for reliability of sequential systems

AUTHOR: B. G. Klimov

SOURCE: Russian Periodical, Vychisliter'naya Tekhnika, Moskovskiy Inzhenerno-Fizicheskiy Institut, Nr. 4, Moskva, 1962, pp. 98-110, Translation prepared by Translation Division, Foreign Technology Division, WP-AFB, Ohio, FTD-TT-63-470/1+2+4, 16 August 1963 (DDC AD No. 420763)

PURPOSE: To demonstrate that the exponential law of reliability is an intrinsic property of practical systems consisting of a large number of elements and to formulate a limiting law for the reliability of series systems.

ABSTRACT: A limiting law of reliability of sequential systems is proven and may be formulated as follows: If the hazard function of each element forming a complex "series" system is negligible in comparison with their sum, then, regardless of the laws of distribution of the reliabilities of the elements, when their number is increased without bound the distribution of the probability of failure-free operation of the system approaches an exponential distribution. A series system is one in which the system fails if any element fails.

REVIEW: This is a mathematical paper, the essential effect of which is to provide a strict theoretical basis for the application of the exponential distribution to independent series systems. Since the exponential distribution and the conditions for its application have been so well covered in the American literature, this paper is of no great practical interest. ##

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R E L I A B I L I T Y A B S T R A C T S
A N D T E C H N I C A L R E V I E W S

TITLE: An accelerated method of measuring semiconductor device reliability

AUTHOR: C. J. Van Leeuwen, Northern Electric Company, Ltd., Research and Development Laboratories, Ottawa

SOURCE: Canadian Electronics Engineering, November, 1963, pp. 42-46 (Based on a paper presented at the Canadian Electronics Conference, October, 1963)

PURPOSE: To explain some accelerated tests on some NPN silicon planar transistors.

ABSTRACT: We are in a position to look upon reliability as another semiconductor device parameter which, like current gain or voltage breakdown, can be measured; but the approach is different. In a relatively short time semiconductor devices can be tested for reliability. Long-term life-test aging, at levels lower than maximum rated, are underway to verify results published in this article.

The study reported in this paper brought to our attention the necessary device modifications (already implemented) to eliminate prevailing failure mechanisms. It is expected that this will reduce failure rates substantially.

The latest experiment of continuous power aging at higher than maximum permissible levels has not generated enough failures to enable us to draw definite conclusions about the end effects of burn-in. Until this conclusion is reached, the required burn-in cannot be optimized to improve reliability.

To upgrade the validity of future aging studies in the stress-aging time domain more intermediate points at the accelerated levels will be required. The significance of end-point limits is directly related to the ultimate reliability target set differently for each piece of equipment.

The identification of the type of underlying failure mechanism giving rise to one or more failure modes is extremely important. Without this knowledge one would only be able to state reliability figures without having the least hope of improving them. (Author in part)

REVIEW: This paper treats degradation failures; catastrophic failures, if they occurred, are apparently treated no differently. Gaussian and log-Gaussian distributions of failures are used. While the work itself appears to have been well done, the presentation of the analysis is not always clear. For example, it is stated that

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

a linear plot on Gaussian probability paper implies only one dominant failure mechanism. The reasons for this are not immediately obvious. Figure 6 is confusingly explained. The least squares method of calculating lines in Figure 7 is probably inaccurate (unless special techniques are employed) since the data are highly correlated. There appears also to be a tremendous amount of scatter in the data.

The discussion of physics-of-failure is good and the points generally are well made. An initial point about a collector emitter field's sweeping out ionic contamination is confusing.
##

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64N24173

Serial Number 2092
ASQC Code 090

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Air Force Flight Test Center reliability literature survey

AUTHORS: Clarence L. Roberts, Captain, USAF and Woodson M. Fountain, 2nd Lieutenant, USAF, Air Force Flight Test Center, Edwards Air Force Base, California, Air Force Systems Command, United States Air Force

SOURCE: Air Force Flight Test Center Technical Documentary Report Number FTC-TDR-63-13, April 1963, 218 pp. (DDC AD No. 401902)

PURPOSE: To create for engineering and management personnel a ready reference to literature existing at the Air Force Flight Test Center (through December 1962) on the rather fragmentized subject of reliability.

ABSTRACT: There have been many articles and papers published on the subject. In an effort to set up a Reliability Library at the AFFTC, many of the more significant of these documents have been procured and are physically located at the AFFTC Technical Library. In addition to these specially ordered documents, all unclassified literature at the Technical Library was surveyed to locate and reference all information relevant to the subject of reliability.

Consequently, there is material included on contracting, designing, predicting, testing, and organizing for reliability. There are articles on testing to failure, testing to destruction, testing for effect of vibration, testing combined environment. Such areas as management, mathematics, maintenance and the military aspects are also well covered.

In addition, the Appendix portion of this report contains a Reliability Bibliography prepared by the Defense Documentation Center (DDC - formerly ASTIA) of all reliability literature which can be obtained from that organization upon authorized request. Current Military Standards and Specifications on reliability, maintained by the Technical Order (T.O.) Library Section within the Quality Control Office of the 6515th Maintenance Group, have also been researched and included in the Appendix portion.

There are about 1000 entries each with a very brief abstract. There is no critique. (Authors in part)

REVIEW: The material appears to be well indexed and should be useful to one interested in a literature search. The DDC listing of reliability papers is probably not complete since many papers pertinent to the subject do not have the "reliability" descriptor. ##

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7/65

64N21563

Serial Number 2093
ASQC Codes 712;715;782

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Effects of reactor radiation on ceramic-bonded solid-film lubricants

AUTHORS: F. A. Haley and R. H. McDaniel, General Dynamics, Fort Worth

SOURCE: Doc. No. NARF-63-6T MR-N-302, 28 pp., issued by the Engineering Department, USAF Nuclear Aerospace Research Facility, General Dynamics/Fort Worth, 30 August 1963, Contract AF33(657)-7201 (NASA accession number N64-21563; DDC AD No. 417167)

PURPOSE: To report wear life and performance of solid film lubricants which have been exposed to high-intensity nuclear radiation.

ABSTRACT: Two irradiated solid film lubricants ($PbS + MoS_2 + B_2O_3$ and MoS_2+ graphite + sodium silicate) formulations were bonded to test cups with Inconel X substrate for test on a Hohman A-6 wear tester. A third formulation (CaF_2 + Oxide frit) was investigated, but it was not irradiated because its coefficient of friction was not compatible with the wear-life tester. A test load of 110 pounds was applied to the cups through each of two Rex AAA steel rub shoes at a sliding speed of 128 feet/minute (355 rpm). Each test was automatically cut off at a coefficient of friction of 0.4. Several test temperatures up to 1200°F were investigated.

The specimens were irradiated for 60 hours with a Ground Test Reactor to an average gamma dose of 1.47×10^{11} ergs/gm and neutron flux of 2.85×10^{16} n/cm^2 (E > 2.9 Mev). The $PbS + MoS_2 + B_2O_3$ lubricant ran with a coefficient of friction near 0.4 throughout the tests. The MoS_2 + graphite + sodium silicate lubricant had a starting coefficient of friction of 0.07, which increased steadily throughout the test to cut-off (0.4). The irradiation had no detectable effect on the wear life of the lubricants (at a 90% confidence level). The $PbS + MoS_2 + B_2O_3$ formulation demonstrated better frictional properties in the temperature range from 850° - 1000°F than at lower temperatures. The wear-life of the MoS_2 + graphite + sodium silicate formulation is 20% better at 600°F than at 1200°F (the difference is significant at a 95% confidence level).

REVIEW: The paper is complete, well written, and easy to read. The authors have included all the pertinent test details, statistical interpretation of their results, and references to future testing in continuation of the program; but they did not attempt to explain the observed temperature effect. The paper should be useful to design engineers. ##

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64A12124

Serial Number 2094
ASQC Codes 711;712;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Low cycle fatigue damage in pressure-vessel materials

AUTHORS: John G. Sessler and Volker Weiss, Department of Chemical Engineering and Metallurgy, Syracuse University, Syracuse, New York

SOURCE: Transactions of the ASME, Journal of Basic Engineering, vol. 85, Series D, pp. 539-547, December, 1963 (Paper No. 62-WA-233)

PURPOSE: To present and discuss experimental evidence on the progress of low cycle fatigue damage in pressure-vessel materials.

ABSTRACT: The damage process that leads to failure of ASTM pressure-vessel steels A302 and A225 in low cycle fatigue was studied by measuring the variation of static properties subsequent to cycling for a portion of the specimen life. Tension-compression cycling was performed at room temperature between controlled strain limits (ϵ_{TR}) at a given strain ratio (R). Room temperature fracture strain and room temperature fracture stress of partially cycled specimens were used to indicate damage accumulation. To assess the effect of crack formation and growth, monotonic tension tests were performed at -320°F on partially cycled specimens. The effects of mean strain on the low cycle fatigue behavior of the materials were studied in order to evaluate the applicability of the equation $N_f = \{(\epsilon_F - \epsilon_o)/\epsilon_{TR}\}^2$. Cyclic tests conducted on the two materials between strain ranges of 0.032 and 0.80 at strain ratios of -1.0 and 0.75 demonstrate good agreement with the equation. This confirms that a tensile prestrain reduces the fatigue life because the fracture strain available for strain cycling is reduced by the amount of prestrain. Fracture-ductility studies on specimens cycled for a portion of their life indicate the equation cannot be used to predict the progress of damage during strain cycling. Strain loss due to strain hardening, a function of the strain amplitude and other factors, is not sufficient to cause failure in the number of cycles predicted by the equation. Final failure in strain cycling results from rapid crack growth at approximately 75% of the specimen life. Fracture occurs when the accumulated strain reaches a constant value as predicted by the failure life equation. However, it is not clear how the loss of available ductility and the formation of cracks combine to give this experimentally confirmed relationship. Further work on strain hardening and crack growth phenomena are recommended.

REVIEW: This paper is a worthy contribution to the literature. The scientist concerned with low cycle fatigue will find it of interest; the design engineer will find the failure life data useful. ##

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63A23895

Serial Number 2095
ASQC Code 712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Further considerations of a theory of crack propagation in metal fatigue

AUTHORS: S. R. Valluri, Firestone Flight Sciences Lab., California Institute of Technology, and J. B. Glassco and G. E. Brockrath, Douglas Aircraft Company, Inc.

SOURCE: 13 pp., presented at the National Aeronautic and Space Engineering and Manufacturing Meeting, Los Angeles, California, September 23-27, 1963, Society of Automotive Engineers paper 752A

PURPOSE: To formulate the fatigue problem in a general manner and to determine the extent to which it explains particular observations.

ABSTRACT: Substantial modifications have been made to an earlier theory of metal fatigue proposed by Valluri. The modifications primarily focus attention on crack growth, appropriate crack growth stresses, and internal stresses presumed to oppose the motion of dislocations. General equations are formulated in terms of the crack growth stresses in the plastic enclave.

In general, the formulated equations gave only a fair correlation with results obtained from tests conducted under constant gross section stresses and constant net section stresses (the equations can be made to fit the test data by varying two available floating constants). For symmetric loads, stress ratio of -1.0, the stress distributions at the crack tip are not symmetric; but they are dependent on the natural plastic stress concentration factor, the gross stress ratio, and the crack length. The internal stresses that oppose the motion of dislocations are presumed to decrease continuously due to fatigue and to give rise to a "nucleation period" in low stress level fatigue. Under constant gross section stress, the rate of crack growth is dependent in the early stages on the half crack length; at a later stage on the square of the half crack length; and still later on the cube of the half crack length; and so on. For a constant net section stress, crack growth is not as strongly dependent on crack length. If the size of the plastic enclave is presumed to depend on crack length, apparently crack growth first increases and then gradually approaches an almost constant value independent of crack length, but strongly dependent on the net section stress and the stress ratio.

REVIEW: The authors have thoroughly analyzed the fatigue theories of other investigators and then developed a general formulation based on modifications of a previous theory. (A typographical error appears in equation 12 on page 4.) The paper is challenging and of considerable value to the research engineer, but it would be of little value to the design engineer. ##

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Serial Number 2096 -1
ASQC Codes 711;712;770

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Crack propagation in low-cycle fatigue of mild steel

AUTHORS: S. T. Rolfe* and W. H. Munse, University of Illinois, Urbana, Illinois (*present affiliation: United States Steel Corporation, Applied Research Laboratory, Monroeville, Pennsylvania)

SOURCE: Ship Structure Committee Serial No. SSC-143, 50 pp., May 1, 1963, Second Progress Report of Project SR-149 under Bureau of Ships Contract NObs-77008, PB181476, U. S. Department of Commerce, Office of Technical Services, Washington, D. C., Price $1.50 (DDC AD No. 410458) but see 63A19330, 66N81091

PURPOSE: To investigate crack propagation in low-cycle fatigue of mild steel plate specimens.

ABSTRACT: Reversed axial loading has been used to investigate crack propagation in low-cycle fatigue of aged and non-aged ABS-C as-rolled-ship steel. The load range applied was varied in order to determine crack propagation at conditions of:

(1) Constant load range where stress increases as a result of the reduction in area due to crack propagation.

(2) Constant stress which requires a reduction in the tensile load range stress as the crack propagates.

(3) Reduced load range where the load range is reduced to establish a constant stress in tension but which results in a progressive reduction of the compressive stress.

The crack growth rate increases continuously at constant load, reduces continuously at reduced load, and remains constant after a brief initial period for a condition of constant stress.

Stresses were localized and studied in a region established by a drilled hole with small saw cuts at the circumference which were perpendicular to the direction of loading. Strain gage and photoelastic measurements were made to determine the stress pattern in the area ahead of the crack front. The stress pattern ahead of the crack changes markedly in small specimens while in large specimens a crack may be large without a perceptible change in the overall stress distribution. The latter suggests that conditions in actual structures are best approximated by laboratory tests employing constant stress loading in conjunction with small crack lengths. Crack propagation at constant stress is divided into three stages:

(1) Initial period where crack growth rate is proportional to crack length.

(2) Linear period during which crack growth rate is constant and is a function of stress.

(3) Final period where edge effects become prominent.

The finding that crack growth rate is constant for a major portion of the fatigue life permits the determination of crack length

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

for any given period.
The results of tests on the specific specimen types establish that:

(a) Crack growth rate decreased for both aged (150°C for 90 minutes) and unaged specimens when temperature is reduced from 75° to -40°F. There was little, if any, difference between aged and unaged specimens at -40°F.

(b) At 78°F the linear crack growth was lower for aged specimens. The relative superiority increased at lower stresses.

REVIEW: This paper deals effectively with testing procedures which can be used in the laboratory to experiment more accurately with crack propagation in large structures. The assumptions made in this respect appear to be valid. The finding that prior load history has an insignificant effect on crack growth at high stress loads should be encouraging to those dealing with the problem of cumulative fatigue damage. The methods used for establishing crack length and stress distribution ahead of the crack front should be of value to anyone interested in similar investigations. Perhaps as work of this nature is extended to include a greater variation in stress levels and for a larger number of cycles, a better concept will be obtained of the mechanics of crack propagation. This paper is an excellent one from the standpoint of both clarity and organization. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Corrosion fatigue of high strength aluminum alloys as affected by notches, anodic metal coatings, and applied cathodic currents

AUTHORS: J. A. Whittaker, H. King, and E. A. G. Liddiard, Fulmer Research Institute Ltd.

SOURCE: S&T Memo 6/63, 25 pp., Report of work carried out by Fulmer Research Institute Ltd. under Ministry of Aviation Contracts KS/1/02/CB.43A(2) and KS/1/029/CB.43(a)2 (DDC AD No. 415264)

PURPOSE: To report the effects of notches and surface treatments on the corrosion fatigue properties of high strength aluminum alloys.

ABSTRACT: Axial fatigue tests (mean stress of 1.1 times the alternating stress) and rotating bend fatigue tests were conducted at 3000 and 2850 cycles/minute, respectively, to study the effects of several variables on the corrosion fatigue properties of DTD.683, H15, and DTD.687 aluminum alloys. The variables considered were: grit blasting, anodic metal spraying, electropolishing, notches, testing speed, and applied cathodic currents. Some tests in indoor and outdoor atmospheres were conducted at 300 cycles/minute under a periodic 3% NaCl spray. Tests of cathodic polarization were conducted on over-aged and under-aged DTD.683 specimens totally submerged in a 3% NaCl solution.

The introduction of surface stresses by grit blasting reduces fatigue resistance--the coarser the grit, the greater the reduction in fatigue resistance. DTD.683 demonstrated a greater apparent susceptibility to grit size. Electropolishing, as compared to mechanical polishing, also reduces the fatigue limit. DTD.683 and HE15 demonstrated notch (stress concentration factor of 5.1) sensitivity in fatigue. Grit blasting and metal spraying (Al-Zn wire) have no apparent effect on the notch fatigue strength of DTD.683 and H15. Metal spraying does not recover grit blasting losses on unnotched specimens. The slow speed indoor tests give slightly lower fatigue values than the high speed tests, indicating effects due to corrosion. Under the mild corrosion conditions of the slow speed tests, there is little or no apparent advantage gained by metal spraying. Constant current cathodic polarization results in a significant increase in the endurance of DTD.683 at zero mean stress, but it is completely ineffective at a mean stress of three times the alternating stress.

REVIEW: The DTD.683 material is now designated DTD.5054 which is similar to 7075. The H15 material is similar to 2025, and the DTD.687 is also similar to 7075.

There is definite indication that the cathodic polarization tests were replicated, but there is no indication that tests to evaluate

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the other variables were replicated. Furthermore, there is no mention of statistical analysis in this paper; however, the authors may have described their statistical analysis technique in a previous paper, which is referenced. All other experimental details and techniques appear to be adequately described and the discussion of the results is thorough. The data should establish useful guidelines for design engineers. ##

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G

Serial Number 2098
ASQC Codes 817;838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Properties of component standby systems from the reliability point of view

AUTHOR: Masafumi Sasaki, Department of Electrical and Electronic Engineering, Defense Academy, Yokosuka

SOURCE: Electronics & Communications in Japan, TK7800-E66, October, 1963, pp. 13-22

This paper is closely related to that covered by Abstract and Review Serial Number 978. The same review applies to this except that more recent work by another author has made the results more accessible (see Abstracts and Reviews Serial Numbers 1267 and 2023). ##

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64N18558

Serial Number 2099
ASQC Codes 431;711;713

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Random-sine fatigue data correlation

AUTHOR: L. W. Root, Collins Radio Company, Cedar Rapids, Iowa

SOURCE: 7 pp., presented at the 33rd Symposium on Shock, Vibration, and Associated Environments, Washington, D. C., December, 1963; published in Bulletin No. 33, Part II, Shock, Vibration, and Associated Environments, February, 1964 (NASA accession number N64-18558)

PURPOSE: To verify a technique suggested in "Random Vibration in Mechanical Systems" by S. H. Crandall and W. D. Mark for predicting the random fatigue curve from the sine fatigue curve.

ABSTRACT: The expected cumulative fatigue damage for random fatigue data has been related to

(1) The Rayleigh probability distribution for the peak stress amplitudes.
(2) The Palmgren-Miner hypothesis of fatigue damage accumulation.
(3) The equation for a straight line fit of sine fatigue data based on a Log S - Log N plot.
(4) The characteristic frequency of narrow band fatigue data which is assumed to have uniformly spaced zero crossings.

The above are mathematically combined to give an expression from which a relationship is obtained that gives the ratio of the rms random stress to the peak sine stress versus the stress exponent of the sine fatigue equation.

The stress exponent of a sine fatigue equation (based on test results obtained using procedures described in the paper) is used to establish the ratio of the rms random stress to the peak sine stress. A predicted random fatigue curve calculated from this ratio is compared to a measured random fatigue curve calculated from random stress test data. The predicted random fatigue curve was found to be conservative but still within one order of magnitude from the measured random stress fatigue life. Possible reasons for the differences are suggested.

REVIEW: The technique employed should be of particular interest wherever the statistical parameters of the stress distribution are known. Modification of the Rayleigh distribution is necessary where, as suggested by the author, damping is nonlinear or where there is truncation of the Gaussian probability distribution function.

The paper covers the material in a rather brief but effective style which relieves the reader from trivia. It is recommended to anyone engaged in the design and/or testing of structures subjected to random loading. ##

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64 N14020

Serial Number 2100 -1
ASQC Codes 512;711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Probability and scatter in cumulative fatigue damage

AUTHOR: Lloyd Kaechele, The RAND Corporation, 1700 Main Street, Santa Monica, California

SOURCE: Rand Corporation Memorandum RM-3688-PR, 77 pp., December, 1963, prepared for USAF Project RAND Contract No. AF 49(638)-700 (NASA accession number N64-14020)

PURPOSE: To investigate the uncertainty factors resulting from scatter in fatigue life and their importance in the design of aircraft.

ABSTRACT: Fatigue life scatter creates uncertainties which complicate the design of aircraft. There are also uncertainties in the number and magnitude of cyclic loads encountered by individual aircraft which make it practically impossible to establish directly-applicable experimental data. Constant amplitude fatigue data is therefore used in conjunction with a cumulative fatigue damage theory to determine the fatigue life expected under conditions of varying loads. The effect of scatter in fatigue life on fatigue design is shown to be comparable to the effect of scatter of yield strength on static design in terms of changes in design weight versus failure probability.

The choice of the failure probability distribution may lead to large differences in predicting the cycles to failure for different probability levels; however the choice of the failure probability distribution is shown to have little effect on design weight.

The confidence level is of great significance since the number of tests made, either real or simulated, are limited because of the cost involved. The construction of confidence regions for the true population mean and standard deviation is illustrated by using the normal (Gaussian) distribution for the sample mean and the chi-square distribution for the standard deviation. A more efficient method for establishing the confidence region is based on acceptance-inspection plan techniques. The latter employs the sample mean and standard deviation along with a "k" factor (obtained from tables, using the specified failure probability, the desired confidence level, and the number of test results) which is used to multiply the sample deviation to obtain the confidence interval.

Since higher loads and cycles than those used for calculations should be anticipated in service, factors of safety are applied to both load and cycles. A design problem, used to illustrate the use of these factors, illustrates the greater sensitivity to load than to cycles that is typical of fatigue.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

The possibility of cumulative fatigue calculations on a different damage concept is suggested. This concept is based on changing the damage level associated with S-N curves to an earlier level, at about one half the fatigue life, which is said to coincide with the transition from intragranular effects to the region where intergranular effects predominate. This changes the stress level of S-N curves only 10 to 15% and offers the possibility of less scatter and perhaps a simpler theory for cumulative damage.

The scatter found in constant amplitude S-N curves is stress-dependent, which complicates the extension of such data to cumulative damage calculations. The effect of this non-uniform scatter may be accounted for by applying a scatter factor to the median S-N curve in order to establish a curve for use in cumulative damage calculations. The assumption is made that in spectrum loading scatter is independent of stress level. This assumption appears to be justified by an analysis of a large number of spectrum test results. A composite standard deviation calculated from these results provides a good fit to the data and leads to the calculation of a scatter factor. This scatter factor is then applied to the median S-N curve to establish a new S-N curve for use in cumulative damage computations.

It is also pointed out that basic S-N data can be converted into S-N curves for design use through the use of the "k" factor previously discussed for establishing confidence intervals whether or not the scatter is stress-dependent.

REVIEW: This paper will be of interest to those involved in designing structures which will be subjected to spectrum loading with the requirement of low probability of failure. A basic knowledge of statistics is needed to understand the ideas expressed. The paper first gives the impression of a collection of unrelated ideas, but this is soon overcome when the material is reviewed collectively. The use of constant amplitude fatigue data for extension to cumulative fatigue damage calculation is treated with some rather interesting approaches. ##

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8/65 66 A 28796 Serial Number 2101
ASQC Code 817

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A trade-off history for a high reliability program

AUTHOR: W. R. Burkhalter, Reliability Engineer, Electro-Mechanical Research, Inc., Sarasota, Florida

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 168-179

PURPOSE: To emphasize the necessity for reliability personnel to participate in informal trade-off decisions since they may have a very important bearing on system reliability.

ABSTRACT: In any development program involving high-reliability equipment, certain decisions must be made regarding reliability, cost, schedule, and performance. These decisions can result in enhancement or degradation of system effectiveness, depending on the wisdom, foresight, experience, and information used. They constitute a series of trade-off studies which may be of the formal type or of the informal type which involves a practical decision based largely on the engineer's best judgment. This paper is concerned with the informal type of trade-off study, and the necessity for reliability personnel and design engineers to work closely together in such studies.

This paper illustrates the importance of daily trade-off studies during the development phase of high-reliability satellite equipment through a discussion of their use on Project Celescope. The nature and purpose of the satellite are described. Problem areas include detail part selection, welded cordwood construction versus soldered printed circuit cordwood construction, use of integrated or thin-film circuits, use of redundancy in the binary elements, camera unit configuration, and optical redundancy for the camera unit. The conclusions are summarized. Important among these is the one that reliability and design engineers can do their jobs more efficiently and more economically when they work closely together.

REVIEW: This is a well-written paper on a worthwhile topic. The material is presented concisely but in sufficient detail to make it quite informative. For those concerned with the type of studies described, the paper is worthy of thoughtful consideration, mainly on the general principles involved, and the ways in which they can be applied to specific situations. ##

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66A28797

Serial Number 2102
ASQC Code 831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Research in the functional analysis of systems

AUTHOR: C. L. Britt, Radiation Systems Laboratory, Research Triangle Institute, Durham, North Carolina

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 198-219

PURPOSE: To present the application of a general probabilistic modeling technique for reliability to a specific electromechanical system.

ABSTRACT: Techniques for reliability analysis developed in a recent study should prove useful in the early stages of an equipment development when the complete system may not be available for test and the operating environment is only partially known. Reliability is defined in terms of the behavior of selected performance attributes, which are assumed in general to be random processes arising from the combined effects of element structure, input signals, power, and environmental stresses. The techniques are applied to a stabilization mechanism for an aircraft radar antenna, which includes a rotary inverter, amplifier, gyro, and torque motor. Tests were run on the major components, and the data were used to construct an analytical-empirical model of the system. Approximations and assumptions are pointed out, as well as the difficulties in the application of the general mathematical techniques in a realistic situation. The detailed construction of the system model is described. Numerical examples are provided, demonstrating the usefulness of the model in the evaluation of a tradeoff between component parts and performance, and in the evaluation of the effect on reliability of the specifications at the interface of two major components of the system. (Author in part)

REVIEW: This paper outlines the objectives, procedures, and interpretation of the application of a probabilistic model to system analysis. Unique features of the approach are that it (1) considers simultaneously an environmental input, a physical input, a supply voltage input, and a number of internal characteristics, (2) treats some variables as distributions and others as drift over time (probabilistic process), (3) includes a dynamic (transient) characteristic, (4) utilizes statistical regression techniques to obtain parts of the model, and (5) explicitly considers both drift and catastrophic failure modes. These are generally treated separately rather than simultaneously. Applications of these principles should lead to a more comprehensive mathematical description than is normally developed in reliability analyses. The presentation is clear and adequately illustrated in general, although there is some poorly defined notation, particularly on p. 201. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Commercial design review and data analysis program

AUTHORS: Richard M. Jacobs and H. Donnell Hulme, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 229-241

PURPOSE: To enumerate the steps taken in implementing and coordinating a Corporate Design Review procedure, and a Corporate Malfunction Reporting, Analysis and Action procedure.

ABSTRACT: This paper discusses two key elements of the reliability program of the Westinghouse Electric Corporation. These elements are design review, and malfunction reporting analysis and action. Of five elements of the program which are listed, design review is considered to be one of the most rewarding financially, and the one which can be implemented with the least investment. Malfunction reporting analysis and action is difficult and time-consuming to install, and takes the longest to prove its value.

The practical considerations essential to a successful design review program are listed. The major items in design review procedure are summarized. Several management aspects not directly concerned with procedure are mentioned. Several case histories are described.

The considerations involved in the development of a data reporting system are discussed, including the essential functions of the system and the prime sources of useful data. Several case histories in this area are described. The importance of obtaining valid data at the lowest possible cost is emphasized.

REVIEW: This is a good paper in its topic area, and serves its purpose quite well. The case histories (with specific product identification deleted for proprietary reasons) lend clarity and authenticity to the discussion. An important point made by the authors, and one which they have kept in mind, apparently, in preparing this paper, is that it is the basic philosophy which has carry-over value to other programs. While the specifics of implementation will differ between companies, certain basic principles are common to all. The manager who gets a clear view of the over-all forest before trying to deal with the individual trees is the most likely to have a successful program. ##

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Data analysis in physics of failure studies

AUTHOR: James R. King, Specialist, Data Systems Division, Autonetics Division of North American Aviation, Anaheim, California

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 242-248

PURPOSE: To consider the use of distribution analysis of parameter changes in electronic components in order to define failures in a statistical sense.

ABSTRACT: One of the more serious and recurrent problems which arises in the failure analysis of electronic components is the necessity to use mostly catastrophic failures for a post-mortem analysis. Very frequently, such parts are already damaged to the point where it is difficult, if not impossible, to make a positive determination of the actual failure site. In those cases where the site can be determined, there is always a substantial suspicion that the detected failure indication was itself the result of a more subtle cause of failure which is being masked by the grosser failure mode and its associated catastrophic failure damage.

There is therefore a need for some method of establishing the existence of a failure mechanism without waiting for a catastrophic failure to occur. Ideally, the optimum method is to be able to establish failure by means of a parameter measurement. In many cases where other than catastrophic failures are used for failure analysis, failure to some specification limit is used to establish the existence of a failure condition. This system has two major drawbacks. First of all, if the specification is a very tight one, then values falling outside the specification limit may be due more to difficulty in making suitably precise measurements than to any determinable physical aberrations in the parts themselves. Secondly, if the specification is relatively loose, a part may be detectable as a significant odd-ball long before it has exceeded a specification limit because of its behaviour.

Another problem in defining parts for failure analysis lies in the manner of utilization of parameter information taken on parts. In many cases, for one reason or another, attention is given only to the absolute magnitudes of the values which are measured. However, for the purpose of determining those parts with unusual, pathological or odd-ball behaviour, the amount of change in the parameter measured may be the real variable of interest.

In this paper, consideration is given to the use of distribution analysis of parameter changes in order to define failures in a

statistical sense. This is done in order to remove the sometimes artificial restrictions imposed by the use of arbitrary specification limits or catastrophic failure behaviour as a source of inputs for careful physics of failure analysis. This has become both more necessary and desirable as advanced analytical tools become more common such as electron microscopes, infrared scanners and mass spectrographs. The additional problems imposed by the behaviour of parts with multiple ratings such as capacitors and resistors are also examined. (Author)

REVIEW: This paper treats an important practical topic. Certainly it would be extremely valuable to be able to detect failure symptoms in electronic components from parameter drift data, and this paper indicates a general approach to the problem. Some of the difficulties are also pointed out. These include the need for sufficiently sensitive and accurate data, which is complicated by the fact that in high-reliability components, drifts are very small over relatively long periods of normal use. However, non-typical drift rates are likely to be more easily detected before they lead to catastrophic failure. This means that the engineer must have a knowledge of typical drift rates as well as considerable relevant data on the components being considered. ##

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Serial Number 2105
ASQC Code 120

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability in soldering--not a myth

AUTHOR: H. H. Manko, Director, Solder Research & Development, Alpha Metals, Inc., Jersey City, New Jersey

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 249-256

PURPOSE: To present those simple, straightforward steps required for proper material selection, design, and process control which make soldering a highly reliable and economical joining method.

ABSTRACT: This paper traces the progress made in soldering from the "soldering bit" to the "micromodule," in order to show that soldering is not "an art" but rather "an engineering science." With proper material selection, design, and process control, soldering can be a highly reliable and economical metallurgical joining method. Once the principles of design are incorporated in the assembly, meaningful inspection of solder joints and continuous monitoring of quality are easily established and maintained.

Material selection must follow certain chemical and physical rules, with special emphasis placed on chemical and galvanic corrosion problems, etc. The design of the solder joint should take into consideration the current-carrying capacity of the joint, the mechanical strength required and the appropriate configuration of the connection necessary to employ mass production techniques.

In order to emphasize the importance of evaluating the various metal joining methods prior to the design stage, nondestructive techniques resulting in meaningful quality control for soldered connections (e.g. 100% inspection, etc.) are compared with the statistical sampling plans employing destructive evaluations which are mandatory for all other joining methods.

New concepts in fluxing for the electronics industry are introduced in this paper and proper post-solder cleaning techniques and contamination levels are discussed. (Author in part)

REVIEW: Those who are interested in reliability in soldering will find this paper of interest and value. The material is presented concisely, and those desiring to go into the details will undoubtedly wish to refer to the book on which the paper is based: "Solders and Soldering," by the author, McGraw-Hill Book Company, 1964.

For a good collection of papers on the features of various methods of electrical connection, see RATR 1663. ##

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66 A28800

Serial Number 2106
ASQC Codes 710;770;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure detection in parts

AUTHOR: L. G. Reynolds, Staff Reliability Engineer, Martin Company, Orlando, Florida

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 270-276

PURPOSE: To point out some of the problems of failure detection in parts and to make some recommendations for their solution.

ABSTRACT: Part failure rate data presently available are unsatisfactory. The data stem from a conglomerate of part testing, system testing, storage, operating, non-operating, and other conditions and the data are not segregated accordingly. The evolution of present part failure detection methods is described. The part may fail under humidity, vibration, shock, acceleration, fungus, salt spray, or other environmental stresses and these facts are not divulged in the data. In another area, part failure rate data should be tailored to the particular type of system under consideration. Many systems are capable of overlooking part failure and degradation because of their design. Logic networks are particularly tolerant of disabled parts. The interrelationship between part sampling and screening plans and part reliability is examined.

Recommendations made in the paper include the following:

1. Accurate failure rate data for parts must be supplied in more specific categories.
2. Consistent definitions should be generated for part disablements to eliminate the great confusion over minor, major, and critical defects and failures.
3. Studies are needed to determine the probability of detecting a disabled part at the part, module, subsystem, and system level; to explore methods for designing systems which can ignore part failures to the greatest practicable degree; and to determine methods of discovering incipient defects before incorporation into assemblies. (Author in part)

REVIEW: This is a short, straightforward paper which states problems of practical importance. The solutions are extremely difficult which, of course, is why the problems have not yet been solved. ##

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Serial Number 2107
ASQC Code 810

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability management of space subsystems

AUTHOR: Melbourne D. Johnson, Santa Barbara Research Center, A Subsidiary of Hughes Aircraft Company, Goleta, California

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 292-299

PURPOSE: To discuss some aspects of the management of reliability programs for spacecraft projects.

ABSTRACT: The management of reliability programs for space-qualified subsystems must consider the characteristics and problems of each project with the emphasis on high reliability, limited quantity, short delivery, and contract incentives. The limited quantity and short delivery requirements indicate that conventional reliability and quality control activities normally associated with aircraft, missile, and production type programs must be carefully considered to avoid the application of ineffective and incompatible tasks. Consideration should be given to: (1) varied contractual reliability requirements, (2) varied mission and operational requirements, and (3) varied customer reliability concepts. Limited quantity has a considerable impact on reliability in that quality control methods involving large production quantities are not applicable, and reliability advantages gained in part and component procurements are compromised. The short delivery requirement also makes its mark on reliability in that (1) insufficient time is available for study and consideration of best design, (2) parts, components, and materials selection and qualification may be limited, (3) quick fixes of marginal designs or failures are encouraged, and (4) insufficient time is available for evaluation and qualification of a developmental model.

These factors indicate that a specific project reliability program must conform to the unique requirements of the contract to be efficient and successful. People, funding, and time must be directed to those areas where the maximum reliability benefit will be realized. (Author in part)

REVIEW: This is a concise paper on reliability management for spacecraft projects. The principles have applicability to various programs, although the specifics of implementation will differ from one project to another. An important point which is clearly brought out is that the program should be designed to meet the unique requirements of the contract, and that blind standardization of programs is neither necessary nor desirable. One should be constantly aware that idealized descriptions of a reliability organization rarely correspond to the way it works in practice. ##

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Serial Number 2108
ASQC Code 800

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Warranty analysis: industrial and commercial product reliability

AUTHORS: Paul Gottfried and Ralph L. Madison, Booz-Allen Applied Research Inc., Bethesda, Maryland

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 300-305

PURPOSE: To discuss some problems associated with warranty analysis for reliability purposes.

ABSTRACT: The sales aspects of warranties are not considered here--only the reliability aspects. Two data sources are specific field service records and historical information on similar elements; these are supplemented by engineering analyses. The raw warranty data are not necessarily descriptive of the physical facts for several reasons--human failings not being the least of these. An example is given of a machine whose warranty was to be extended. The data were analyzed, taking into account the human problems of distorting the facts. Some parts were associated with the largest "failure" rates and a redesign was made to improve the situation. A failure experience was predicted and compared with actual experience. The fit is quite good.

REVIEW: This is a rather general paper, as befits an oral presentation. Upon close inspection, some of the ideas are not presented in enough detail to really tell what is going on--especially with regard to failure models. The paper does mention the difficulties inherent in analyzing warranty data. Apparently, detailed models for their analysis are rather hard to come by and human failings play a large part in the nature of such models. (There is some uncertainty about the meaning of "theoretical analyses" and what other analyses they are distinguished from.)

The subject is, or should be, of considerable interest and this paper provides a good introduction to it. ##

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8/65 66N28804 Serial Number 2109
ASQC Codes 817;825;873

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Exploiting the reliability-maintenance relationship for manned missions of extended duration

AUTHORS: J. W. Griswold and R. C. Schneider, Aero-Space Division, The Boeing Company, Seattle, Washington

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 319-328

PURPOSE: To discuss some aspects of the reliability-maintenance relationship.

ABSTRACT: Traditional reliability design concepts, including the use of extensive redundancy, fail to achieve the necessary reliability potential required for long term orbital and space missions. The time factor, alone, is sufficient to offset the advantages gained by redundancy, quality of parts, and other improvement methods. A design and operational approach allowing system restoration through maintenance can significantly arrest reliability degradation for missions extending up to several years. This approach is predicated on dealing with configurations tolerant of single failure conditions such that required system performance can be maintained while equipment is "down" for maintenance.

The paper discusses some facets of the reliability-maintenance relationship including accessibility, spares, crew duty cycle, and design standardization. Reliability evaluation models are derived as functions of equipment failure rates, number of restorations and maintenance down-time for parallel and standby equipment arrangements. An example application demonstrates the effectiveness of the maintenance approach by showing achievement of an acceptable reliability level for a one thousand hour mission while utilizing conservative "state of the art" failure rates. (Authors)

REVIEW: This is an introductory paper on a topic which will become increasingly important with the advent of manned space missions of relatively long duration. The extension of the ideas to complex systems will be necessary. The pertinent mathematical relations for the cases considered in this paper are given in an appendix. (Not all of these were checked.)

It should be remembered that repair is just a special case of standby redundancy. The assumption of negligible failure rate of spares cannot always be made in space systems, especially where failure is due to non-operating conditions such as vibration. True statistical independence of failures in standby spares may be difficult to achieve since the environment is not known exactly. ##

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ASQC Codes 600;810;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The role of system safety engineering and its relation to reliability

AUTHOR: George F. Ruff, Research Specialist, System Safety Engineering, North American Aviation, Inc., Downey, California

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 341-347

PURPOSE: To discuss the role of system safety engineering and its relation to reliability.

ABSTRACT: Much has been said about the new discipline entitled System Safety Engineering. It is understandable that established disciplines look upon System Safety Engineering as an intruder in their established areas of responsibility. The intrusion stems from the requirement for System Safety Engineering to assure that proper action, in the interest of product safety, is taken by the proper disciplines at the proper time so that a common base of safety is established as a normal development process. This action will lead to a product which possesses the potential to be free of hazards. Where the hazard cannot be reduced below a given level of risk, the proper controls will assure that the requirement has been established for proper documentation and devices to protect the product and associated personnel. If every discipline were completely familiar with system safety, there would be little need for the system safety discipline. Since this is not the case, the intrusion is only in the areas where proper action is not being taken on a routine basis.

This paper briefly discusses the role of System Safety Engineering and relates this role to the various disciplines having a major effect on System Safety Engineering. Particular emphasis is given to the relationship of system safety to reliability. The major areas in reliability that have interfaces with system safety are described and the relations explained. The results of the discussion indicate that system safety functions should be included in the management area of Product Quality Assurance, since the quality assurance program should include "engineered" safety in the product. (Author in part)

REVIEW: Safety engineering is obviously one facet of engineering although today's engineers may not do much of it. The setting up of specialized engineering groups to monitor design/production engineers should be regarded as temporary. Given the requirements for a job, such as cost, reliability, and performance, it is the design/production engineer's job to translate them into a product which meets the requirements. If some of the require-

ments should be quite unusual, such as high reliability, he may need the assistance of specialists to help in the design. Thus reliability engineering, safety engineering, etc. should eventually fit in as service organizations. In some cases, the design/production must be monitored to make sure it will realize some of the unusual goals. The management support that is necessary should be no more for safety than it is for reliability, maintainability and other unusual goals. Each one of those subgroups of engineering tends to expand and want total engineering, e.g., total quality control engineering. In the limit, each of these becomes the totality of engineering--all exactly the same thing.

This paper is written in the "systems jargon" with interfaces all over. Obviously, most of the things said about safety are true about other system goals as well,e.g., they must all be re-evaluated when changes are made. They are likely to be achieved only if the design/production engineer is convinced that management really cares about meeting that part of the specification. ##

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ASQC Codes 840;850

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Exponential smoothing for prediction of reliability growth

AUTHORS: Thomas L. Fagan and Myron A. Wilson, General Electric Company

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 353-360

PURPOSE: To present methods of applying exponential smoothing to the measurement and prediction of reliability growth.

ABSTRACT: A frequent problem confronting reliability engineers is the estimation of equipment reliability based on field data. Complex equipments are seldom reliable when first placed in service, but undergo a process of reliability growth as design problems are corrected and as operating and maintenance personnel become more adept. Field data (operating time and number of failures) received as a continuing time series exhibit a high degree of variability, tending to obscure reliability growth trends.

Exponential smoothing is applicable to situations in which we are given a sequence of numbers from a continuing time series, and are required to estimate the values of succeeding numbers from the same series. The technique has several advantages over methods such as least squares curve fitting, moving averages, etc., particularly its ability to "track" the data as closely as desired employing a quite short file of historical statistics for the purpose. These statistics represent all past observations, giving geometrically decreasing weight to older data.

Methods for applying exponential smoothing to the measurement and prediction of reliability growth for estimating the mean and variance of the error distribution are given. (Authors in part)

REVIEW: This paper describes a technique which can be usefully applied in determining reliability growth trends in order to assess the effectiveness of reliability improvement measures. The idea is good and the presentation of it is reasonable, though rather brief. However, the references cited by the authors give more detail. ##

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R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

TITLE: Some properties of the conditional Weibull distribution

AUTHOR: Leo A. Aroian, Reliability Staff, Electronics Division, TRW Space Technology Laboratories, Redondo Beach, California

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 361-368

PURPOSE: To discuss some properties of the conditional Weibull distribution.

ABSTRACT: The mean time-to-failure of all items failing between times t_1 and t_2 for any continuous failure density is derived. The result is used to obtain the mean time-to-failure of conditional distributions starting at t_1. It is shown that for the Weibull density function the mean may be evaluated by the use of either the incomplete Gamma function or the X^2 distribution. Special cases involving the exponential and Weibull distributions are considered, and an example is given.

REVIEW: This is a mathematical paper which makes a contribution to the knowledge of the properties of distributions of times-to-failure. In keeping with this, it does not deal with the type of practical situation to which the results are applicable. ##

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8/65 66 A28809 Serial Number 2113
ASQC Codes 122;221;823;
837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Exceedance theory applied to reliability and quality control problems

AUTHORS: Lawrence Danziger and Stephen A. Davis, I.B.M. Corporation, Poughkeepsie, New York

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 412-428

PURPOSE: To present the application of exceedance theory to reliability and quality control problems.

ABSTRACT: The Normal and exponential distributions have served as models for solving many quality control and reliability problems. However, both of them (and other well known models) have been abused countless times because there was no tangible basis for their choice. To meet the void of "what to do" in cases where one cannot assume some known distribution, techniques known as distribution-free methods are available. These techniques use "the order in which observations become available" as a basis for decision making, regardless of the form of the theoretical model. If one can confidently assume a specific theoretical parent population, then statistically little can be gained from the more general distribution-free methods. However, if such an assumption is doubtful or cannot be made at all, then distribution-free methods should be considered. One such distribution-free function, which is paradoxically called "the distribution of the number of exceedances," has found applications to problems of tolerance limits, life testing, floods, strength of materials, etc. In this paper, the relationship between the one and two partition cases is derived, special useful cases are examined, and an extensive set of tables is provided with emphasis on their use in solving tolerance limit and life test problems. Ten practical examples are presented. (Authors in part)

REVIEW: This paper does a good job of presenting the use of tables of distribution-free tolerance limits in solving certain types of problems in life testing and quality control. Two types of problem which can be handled are those of testing, with stated confidence, whether the lifetimes of one device or material are shorter than those of another, or whether the lifetimes of one device are more variable than those of another. That is, the method applies to the comparison of two devices, materials, or processes, rather than to testing against some pre-selected standards. This is a limitation, but it is well to be aware of such methods and to use them in applicable situations. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Escape probability as a systems design parameter

AUTHORS: John L. Kidwell, Nicholas L. Squeglia, and H. J. Lavender, Lycoming Division, Avco Corporation, Stratford, Connecticut

SOURCE: Transactions Nineteenth Annual Technical Conference, American Society for Quality Control, Los Angeles, California, May, 1965, pp. 486-499

PURPOSE: To discuss the application of the philosophy of escape probability to the design phase of systems development.

ABSTRACT: Escape probability is the probability that a discrepant item will pass through established check points and cause a system failure. This potential degradation factor on systems reliability can be used as a design parameter if it can be quantified. This paper is concerned with an approach to the minimization of the effect of escape probability through the intelligent manipulation of manufacturing degradation factors so as to optimize inspection.

Escape probability, EP, is defined as follows for the cases indicated:

1. Pre-production phase
   (a) Sampling inspection: EP = AOQL/DP
   (b) 100% inspection: EP = PAE(1-DP)
2. Production phase
   (a) Sampling inspection: EP = AOQ/DP
   (b) 100% inspection: EP = PA(1-DP),

where AOQL = Average outgoing quality limit in fraction defective,
PAE = Process average estimate in fraction defective,
AOQ = Average outgoing quality in fraction defective,
and DP = Detection probability of inspection not accepting defective material.

EP is given for systems of components in series or parallel. The use of EP in systems design is discussed. EP allows a quality audit program by exception--i.e., planning for hardware audits only on those critical characteristics previously defined by the designer. Two practical applications are described.

REVIEW: This paper describes one approach to the quantification of escape probability. It is quite simple, easy to understand, and is clearly presented. Its usefulness in practice would appear to depend heavily on the ability to obtain realistic estimates of DP. Carefully designed inspection experiments should be the best way of doing this. Naturally the ultimate objective is to devise ways of increasing DP, thus reducing EP and improving systems reliability. (For another paper on escape probability see RATR 1602.) ##

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Serial Number 2115
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An aspect of second breakdown in transistors

AUTHORS: T. Agatsuma, T. Kohisa, and A. Sugiyama, Musashi Works, Hitachi, Ltd., Tokyo, Japan

SOURCE: Proceedings of the IEEE, vol. 52, pp. 1372-1373, November, 1964 (correspondence)

PURPOSE: To measure various characteristics of transistor second breakdown using shorter pulses than previously employed.

ABSTRACT: The "second breakdown" parameters I_M, T_d, and E_M, previously measured by Schafft and French (see RATR 1347) were remeasured on alloyed junction p-n-p germanium transistors. Schafft and French used a half cycle voltage of 60Hz (a pulse of the same duration as the thermal time constant of the transistor). A much shorter pulse was used in these new measurements. The pulse consisted of a voltage ramp rising to a pre-determined value V_a after which the voltage remained at V_a until second breakdown occurred. Three variables were measured: time, T_d, between pulse initiation and second breakdown; energy E_M, absorbed in the transistor prior to second breakdown; and second breakdown current, I_M. For a constant ramp slope, the values of T_d, E_M, and I_M were found to saturate when V_a was high enough so that second breakdown occurred before or just as the ramp voltage reached V_a. As the slope of the voltage ramp was increased, the saturation values of the E_M and T_d decreased while that of I_M increased, leading to the speculation that second breakdown is restricted to more localized areas with the steeper voltage ramps.

REVIEW: These experiments constitute a well-conceived, significant contribution to the study of second breakdown. The thermal origin of second breakdown suggested by Schafft and French and discussed at length by others (see RATR 1347 and 1378, and also [1]) is simply and clearly indicated in these neat results.

REFERENCE: [1] C. G. Thornton and C. D. Simmons, "A new high current mode of transistor," IRE Trans. on Electron Devices, vol. ED-5, pp. 6-10, January, 1958 ##

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65 A16577

Serial Number 2116
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Turnover phenomenon of $N^+N\ N^+$ plate contact silicon device and second breakdown in transistors

AUTHORS: T. Agatsuma, T. Kohisa, A. Sugiyama, Musashi Works, Hitachi, Ltd., Tokyo, Japan

SOURCE: Proceedings of the IEEE, vol. 53, p. 95, January, 1965 (correspondence)

PURPOSE: To report on some observations of "second breakdown" in a junctionless majority carrier current structure.

ABSTRACT: To avoid the irrelevant complexities of transistors or other minority carrier devices, $N^+N\ N^+$ samples were prepared for the study of "second breakdown" (SB). The samples were prepared by diffusing phosphorus into both sides of various n-type wafers; resistivities were about 4, 28, 50, and 215 ohm-cm. The current-voltage characteristics of all these samples displayed the turnover typically associated with SB at an electric field strength approximately one order of magnitude below the avalanche field strength. The surface temperature at turnover, as determined by temperature sensitive paint, correlated closely with the intrinsic temperature of the lowest doped region of each of the structures. The conclusion is that SB is not peculiar to transistors, but is applicable to any semiconductor device regardless of its physical configuration or function, and is dependent only upon the critical temperature of intrinsic conduction. (Authors in part)

REVIEW: In this and a previous contribution (see RATR 2115), the authors have perhaps finished the task begun by others (see RATR 1347, 1378, 1385, and 1461) of unmasking the mystery of SB. The conclusion, simply stated, seems to be that when semiconductor devices reach intrinsic temperatures they display the electrical behavior which has been characterized as "second breakdown." In any event this experience seems to have completed the trend toward the observation of SB in simpler and simpler structures. Initially SB was regarded as a transistor characteristic (see RATR 1347, 1378 and 1461); then it was observed with only single junction structures (see RATR 1385), and now no p-n junctions at all are required to see the SB characteristics. It will be difficult to get simpler than this. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: "Power-off" time impact on reliability estimates

AUTHOR: Philip O. Nerber, International Business Machines Corporation, Space Guidance Center, Owego, New York

SOURCE: 1965 IEEE International Convention Record, Part 10, New York New York, pp. 1-8, March, 1965

PURPOSE: To detail recently-acquired evidence in support of the existence of "power-off" failure rates for digital equipment.

ABSTRACT: The results of statistical tests and analyses of equipment failure mechanisms support the following conclusions:

1. For a digital guidance computer, the existence of a significant power-off failure risk is evident with high statistical confidence;
2. Estimates of MTBF which consider only operating time are significantly biased in an amount determined by the duty cycle;
3. Although the proposed failure model (the calendar time failures are made up of ON failures and OFF failures, each having its own failure rate) represents the simplest possible extension of present practices, it has been strongly supported by independent data from similar equipments.

On the basis of these conclusions, the present methods of field failure data collection, analysis, and application appear to be outmoded. The traditional practice of using component part failure rates derived from field data to predict the reliability of future equipments, without any regard for the associated duty cycle, can result in erroneous predictions. (Author in part)

REVIEW: This appears to be a good piece of work. While the author presumes that MTBF is calculated only from ON time, a great deal of MTBF data on hand probably deals with some unknown method of estimating time. The examples in the threshold failure mechanism class are not at all clear. (Equation 5 contains some misprints.)

For another paper on the non-operating failure rate see RATR 2009.
##

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Serial Number 2118
ASQC Codes 831;872

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability of a system having standby spare plus multiple-repair capability

AUTHOR: Eginhard J. Muth, General Electric Company, Daytona Beach, Florida

SOURCE: 1965 IEEE International Convention Record, Part 10, New York, New York, pp. 9-15, March, 1965

See also 66A 38 743

PURPOSE: To find the reliability for two units with a limited repair capability.

ABSTRACT: The reliability of a system of two identical and repairable units, one of which is operating, while the other is in inactive standby, is treated. It is assumed that the units have independent exponentially distributed failure times, and independent gamma distributed repair times. The failure rate is λ, and the mean time to repair is τ. Formulas are derived which express system reliability and expected time to system failure specifically as a function of the capability for one repair, two repairs, and so on. Results are presented in graphical form. Important conclusions are: (1) the benefit of repair capability is negligible when $\lambda\tau > 0.5$; (2) the choice of the repair time distribution does not influence the results when $\lambda\tau < 0.2$; and (3) the effect of repair capability is comparable to that of additional standby units when $\lambda\tau < 0.01$. (Author in part)

REVIEW: This is a good paper and the results are readily usable by design engineers. The statements about the usefulness of repair capability as a function of $\lambda\tau$ are especially helpful. The mathematics appears to be of high quality and was not fully checked.

See RATR 2009 and 2117 for examples of systems which have a non-negligible failure rate while they are inactive. The applicability of this model may be limited by the assumption of inactive (zero failure rate) standbys and statistical independence of failures (this presumes that the environment is known exactly). ##

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Serial Number 2119 -1
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Linear strain theory and the Smith Method for predicting fatigue life of structures for spectrum type loading

AUTHOR: Clarence R. Smith, General Dynamics/Convair, San Diego, California

SOURCE: ARL 64-55, 65 pp., April, 1964, prepared by the Fatigue Laboratory, General Dynamics/Convair under USAF Contract No. AF 33(616)-8228 for Aerospace Research Laboratories, Office of Aerospace Research, USAF, Wright-Patterson AFB, Ohio (DDC AD No. 600879)

PURPOSE: To present two methods for predicting fatigue life in structures subject to spectrum loading.

ABSTRACT: Two methods are presented for predicting the fatigue life of structures subject to spectrum-type loading. Unlike the Miner or Palmgren method, these methods consider the effect of the order of loading on subsequent fatigue by evaluating the residual stresses left by high loading.

In the first method, the Linear Strain Theory, it is assumed that the strain at the concentration is proportional to the nominal load and that the actual stress at the concentration can be determined from a stress-strain curve for the material. The net result is that the difference between the material yield stress and values obtained above the yield stress, resulting from the multiplication of the nominal stress times the stress concentration factor, reveals the amount of the resulting residual stress. The residual stress thus obtained permits determining the effective maximum and minimum loads in the load spectrum which can be used in conjunction with conventional S-N data for cumulative fatigue calculations.

In the second method, the Smith Method, it is assumed that in the structure the material at the concentration cannot elongate substantially without yielding the material in the adjacent area. The maximum stress at a concentration does not as a result exceed substantially the yield point for the material if the nominal stress is below the yield point. A cut-off line is constructed on S-N curves for smooth specimens established on the basis of different ratios (R) of minimum load to maximum loads. Using this line and a single datum point for the structure, such that the life obtained is less than that for a smooth specimen cycled at a load equal to the yield-point stress, gives the stress amplitude which is prorated for other loads in the spectrum. Where stress amplitudes thus obtained are greater than the yield strength for the material, the amount of stress greater than the yield is treated as a residual stress and the fatigue life is obtained from the "R" curve corresponding to the ratio of the residual stress (minimum load) divided by the yield stress (maximum load). Test

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

data included in the report indicate a close correlation between actual and predicted values using both methods. Advantages and limitations of both methods are also given.

REVIEW: The paper provides a considerable amount of useful information for those involved in fatigue testing. For the most part the paper is clearly presented with adequate graphical illustrations and mechanical analogies for good understanding. The Smith Method, however, is not as easily understood as the Linear Strain Method. Much has been left to the reader to surmise with respect to how the single datum point is obtained and to the meaning of the cut-off line. The article is, however, well worth reading in spite of these shortcomings.

The Smith Method is quite similar to that discussed by the same author in the paper covered by RATR 1733. ##

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8/65 G

Serial Number 2120
ASQC Codes 844;851

RELIABILITY ABSTRACTS
AND TECHNICAL REVIEWS

TITLE: Reliability considerations in microminiaturization

AUTHOR: I. A. Lesk, Motorola Semiconductor Products Division, Phoenix, Arizona

SOURCE: NEREM Record, Northeast Electronics Research and Engineering Meeting, Boston Section, IEEE, November, 1964, pp. 22-23

PURPOSE: To explain some of the problems in proving long-life for microelectronic devices.

ABSTRACT: Microcircuits now have such a low failure rate that it is difficult to measure under normal operating conditions. Accelerated testing, along with failure mode analysis, is performed to evaluate quickly the quality of the devices. Since several failure modes exist within the same device, and since any stress accelerates each differently, the device must receive a careful physics-of-failure analysis. At times, it is necessary to stress only part of a circuit to avoid causing immediate failure of other parts. If the characteristics drift, as is usually the case, rather than failing catastrophically, the definition of a failure is rather arbitrary. Surface changes are most common and least understood; they generally affect the dc more than the ac performance.

REVIEW: This is a brief outline of the subject and will be of value largely to those not acquainted with reliability testing of microelectronic devices. The content is reasonable and is well presented. ##

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Serial Number 2121
ASQC Codes 775;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Power screening for high power silicon planar transistors

AUTHORS: M. Collins, J. Tenzer and T. Longo, Transitron Electronic Corporation, Wakefield, Massachusetts

SOURCE: NEREM Record, Northeast Electronics Research and Engineering Meeting, Boston Section, IEEE, November, 1964, pp. 90-91

PURPOSE: To explain the need for a non-destructive power screening of transistors and to describe such a test.

ABSTRACT: Transistors sometimes need to be able to control full power and still function as a transistor. Secondary breakdown and thermal runaway are possible failure modes. These failure modes are not detected by the more conventional parameter tests. The burn-in tests which can find this defect are time consuming, expensive, and destroy the non-acceptable units. A miniature burn-in circuit, with properly selected voltages, and an added diode in the base, can be used to prevent destruction of most of the failures. The test may be conducted in free air with the power applied for only a short interval, say five seconds. Rather good correlation was established between this and the conventional burn-in or life test, for this failure mode.

REVIEW: This is a very short description of the test and suffers somewhat because of that. The discussion is worthwhile, however, and non-destructive quick tests are always desirable for measuring parameters related to life.

The first author, in a private communication, has commented as follows: "...I might suggest that stress be placed on proper attention to the details of an operating circuit, that is to keep truly constant those items which are assumed to be so, in particular the time of the free air testing method." ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An innovation in inspection and control...nondestructive metallography and microfractography

AUTHOR: P. A. Jacquet, Engineer for Naval Weapons and Constructions (attached to Armed Forces Technical Services) and consulting engineer with National Aeronautical Research and Development Board and Atomic Energy Commission, France

SOURCE: Metal Progress, vol. 85, February, 1964, pp. 114-116, 146

PURPOSE: To describe and give two examples of nondestructive metallography and microfractography.

ABSTRACT: A new nondestructive method for controlling the heat treatments and microstructures of large components during fabrication is also useful in investigating accidental damage to parts. The technique has three advantages:

1. Preliminary polishing can be done on an area of many square inches; it does not produce a surface defect which might cause a failure in subsequent use.
2. The observation is carried out on a plastic replica; a microscope need not be installed on the piece being inspected.
3. Examinations can be made at all magnifications of optical microscopes (up to 2000 x) and at those of electron microscopes.

A suitably polished surface can be obtained at the desired location by means of the "Ellopol" electrolytic process. A mobile cathode or "plug" whose porous wall retains a small amount of electrolyte is placed on the surface. The cathode can be fixed in position if the area to be polished is about 1/2 sq. in., or it can be moved to polish larger areas. All of the common ferrous and nonferrous alloys and most special alloys or "exotic" metals can be polished with a very limited number of electrolytic compositions.

Examinations are not carried out on the original surface but on a replica obtained by use of a special liquid varnish. The replica is placed on a glass slide and examined by transmitted or reflected light on the metallographic microscope. For electron microscope examinations, the bare replica is covered with a thin film of vacuum deposited carbon. Two examples are given of the practical use of this method.

REVIEW: Nondestructive-testing is most important for insuring high reliability. Designers should be aware of these techniques so that they may specify them. This is a good description of one such method, although anyone using it for the first time will undoubtedly find that experience in it is helpful. ##

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Serial Number 2123
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: How failures occur...
Topography of fracture surfaces
Experiences in the field

AUTHORS: Frank R. Larson and Frank L. Carr, U. S. Army Materials Research Agency, Watertown, Massachusetts

SOURCE: Metal Progress, vol. 85, February, 1964, pp. 74-78 and March, 1964, pp. 109-113

PURPOSE: To show how the appearance of a metal fracture can be used to show the behavior during failure.

ABSTRACT: Most fracture surfaces of tensile and impact specimens have three zones--fibrous, radial and "shear lip." Their presence and respective sizes may vary with the temperature, strength of the material and shape of the specimen. Knowledge of their characteristics aids in identifying the causes of service failures. By knowing these features of fracture surfaces, the origin and type of service failure can often be determined by a simple visual inspection. This applies largely to tensile failures rather than fatigue. Examples are given of brittle and ductile failures in guns, pressure vessels, bolts, and other parts. (Authors in part)

REVIEW: This is a good tutorial paper which bears on physics-of-failure at the applied end of the spectrum. Knowledge about metals failures is, of course, essential in studies of failed parts. While some knowledge of metals and failure is helpful in reading the article, it can be a valuable introduction to the subject.
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64N22595

Serial Number 2124
ASQC Codes 714;716;782

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Investigation of the effect of dry film lubricants on corrosion resistance

AUTHOR: Billie L. Thrasher, Test Engineer, McDonnell Aircraft Corporation, St. Louis, Missouri

SOURCE: Report A753 prepared under Contract No. AF 33(657)-11215 and BPSN: 63-6899-7381-738103 for the Directorate of Materials and Processes (ASRCEM-1), Aeronautical Systems Division, Air Force Systems Command, United States Air Force, Wright-Patterson Air Force Base, Ohio by McDonnell Aircraft Corporation, St. Louis, Missouri (NASA accession number N64-22595)

PURPOSE: To report the effects of dry film lubricants on the corrosion resistance of alloys and their protective coatings.

ABSTRACT: Salt spray corrosion tests were conducted to evaluate the effects of dry film lubricants on the corrosion resistance of alloys and their protective coatings. Three test specimens and a control specimen (no lubricant), representing each of the combinations, were exposed in a 5% NaCl environment until severe corrosion had occurred or 500 hours had elapsed. The lubricants evaluated were: Molykote X-106, Electrofilm 2006, Electrofilm 2306, Everlube 620, and Slip Plate #2. The alloys and coatings tested were: alodined and anodized 7075-T6 aluminum; alodined and anodized 2024-0 aluminum heat treated to T-6 condition; HK31A magnesium with Dow 17 treatment; 6Al-4V titanium; cadmium and chromium plated 4340 steel heat treated to 220-240 ksi; 301 stainless steel, full hard; and beryllium-copper heat treated to HT condition.

The alodined 7075-T6 and 2024-T6 specimens coated with lubricants had considerable corrosion after 18 hours, while there was no indication of corrosion on the corresponding uncoated specimens. Molykote X-106 appeared to promote corrosion of the cadmium plated 4340 steel. Everlube 620 initially retarded the corrosion of anodized 7075-T6 specimens over the uncoated specimens, but this initial protection was lost prior to the 500 hour test termination. Electrofilm 2306 repeatedly washed off the test specimens. In most instances, the corrosion resistance of the alloys was not adversely affected by the coating of dry film lubricants.

REVIEW: The author reports test results, but he does not attempt to analyze or explain them. As is true with most corrosion tests, the results are comparative and statistical analysis was not used. Eleven tables, 36 photographs, and 36 micrographs are included. In the microfilm copy of the report, the quality of the photographs and micrographs is too poor for interpretation. The results of these tests should establish useful guidelines for design engineers. See also RATR 2125, which covers a related report. ##

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64N22596.

Serial Number 2125
ASQC Codes 714;716;782

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Effect of cadmium plate on dry film lubricant wear life

AUTHOR: Billie L. Thrasher, Test Engineer, McDonnell Aircraft Corporation, St. Louis, Missouri

SOURCE: Report A754 prepared under Contract Number AF33(657)-11215 and BPSN: 63-6899-7381-738103 for the Directorate of Materials and Processes (ASRCEM-1), Aeronautical Systems Division, Air Force Systems Command, United States Air Force, Wright-Patterson Air Force Base, Ohio by McDonnell Aircraft Corporation, St. Louis, Missouri (NASA accession number N64-22596)

PURPOSE: To report data concerning the effects of cadmium plate on the wear life and the corrosion resistance of bearings coated with dry film lubricants.

ABSTRACT: Cadmium plated and unplated 4130 steel test cups (heat treated to 180-200 ksi) coated with Molykote X-106 dry film lubricant were tested on a MacMillan lubricant tester at 80 rpm and 630 pound line contact load applied through a 52100 steel rider (Rc 52 hardness). The corrosion resistance of the cadmium plate was evaluated by subjecting both plated and unplated test cups to alternate four hour wear tests on the MacMillan tester and twenty-four hour exposure to a 20% salt spray until a running coefficient of friction of 0.2 was obtained for the wear test portion of the cycle.

The average wear life of the cadmium plated test cups was 13.3 hours as compared to 23.0 hours for the average wear life of the uncoated cups. Considerable corrosion was observed for both the plated and unplated test cups after the first twenty-four hour salt spray exposure of the alternate corrosion-wear test. The cadmium plate substrate decreases the wear life of the dry film lubricants, and it appears that Molykote X-106 dry film lubricant may be detrimental to the corrosion resistance of cadmium plate.

REVIEW: The author contends cadmium plate decreases the average wear life of the lubricated surfaces by 40 per cent, which is true; however, the average wear life may not be significant. The averages were calculated from three (8.6, 24.7, and 6.5) and two (15.9 and 30.1) data points with considerable overlap. The author does not attempt to explain the observed behavior.

The results may be useful as design guidelines, but they are rather inconclusive. See also RATR 2124, which covers a related report. ##

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Serial Number 2126 -1
ASQC Code 775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: IR techniques for electronics: latest progress in R & D and applications

AUTHOR: Riccardo Vanzetti, Raytheon Company, Norwood, Massachusetts

SOURCE: 22 pp., presented at the 3rd Annual Meeting of the Infrared Techniques for Electronics Committee, Huntsville, Alabama, February, 1964 (Proceedings published by The Society for Nondestructive Testing, Inc., 914 Chicago Avenue, Evanston, Illinois, October, 1964)

PURPOSE: To review the progress made to date in the field of infrared techniques for electronics, to describe recent findings and applications, and to indicate progress toward full utilization of the techniques.

ABSTRACT: Much progress has been made in the field of infrared (IR) techniques for electronics. The year 1963 marks the transition from sporadic probing of possibilities to the first systematic applications for (a) electrical design evaluation, (b) product design evaluation, and (c) production quality control. But the probing is not over; not all areas of interest have been explored. IR test equipment especially designed for systematic applications for every type of electronic unit is not yet generally available. However, IR evaluation of design and production of electronic units is now systematically implemented for some programs.

The following key areas of R & D work in IR were outlined by the author in 1961: (1) Coating material, (2) Fibers, (3) Recombination radiation, (4) Detectors and cryogenics, (5) New encapsulation for semiconductors, (6) Image converters, (7) Optics and scanning, (8) Correlation studies, (9) Microwave guides, (10) Weld tester, (11) Mechanical resonances, (12) IR microscope, and (13) Information display. The progress in these areas is evaluated; it ranges from good to none. A revised set of task descriptions is given in an appendix.

Other topics covered include: difficulties in the availability of suitable detecting and measuring equipment, and progress made in overcoming them; fast operation; repeatability; accuracy; thermal intereffects; IR translucent materials; electrical intereffects; engineering evaluation, and production quality control. Several areas of advance study are outlined.

REVIEW: This paper accomplishes its purpose well, and in so doing packs a lot of information into a relatively short space. For those who are interested in the use of IR techniques in reliability improvement and other areas, it is fundamental reading. The author is the scientist who has pioneered this field and who continues to

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be a prime mover in its development.

An important feature of this paper is the appendix in which the author presents a description of 13 key work areas in his basic R & D plan to advance the use of IR techniques for reliability and maintainability improvement of electronics. It should be considered carefully by those interested in advancing the state of the art in this field. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability screening using infrared radiation

AUTHOR: Anthony J. Feduccia, Rome Air Development Center, Griffiss AFB, New York

SOURCE: 9 pp., presented at the 3rd Annual Meeting of the Infrared Techniques for Electronics Committee, Huntsville, Alabama, February, 1964 (Proceedings published by The Society for Nondestructive Testing, Inc., 914 Chicago Avenue, Evanston, Illinois, October, 1964) but see 64A22068

PURPOSE: To describe investigations leading to the development of a nondestructive infrared test for detecting potential early part failures before the parts are used in a circuit.

ABSTRACT: The infrared (IR) radiation emitted by electronic parts may possibly be used to (1) identify short-life or faulty parts and (2) predict the reliability of circuits and subassemblies. It has been shown that parts emitting abnormal amounts of IR under the same stress conditions tend to experience early failures. This paper deals with the investigations leading to the development of a nondestructive infrared test which can ferret out potential early part failures before the parts are used in a circuit. Investigations into the use of radiometric techniques combined with high-resolution scanning to form thermal images for reliability analysis are also included.

The results of investigations carried out at Rome Air Development Center on transistors, thin-film resistors, and metal film resistors are summarized. The advantages of IR techniques are pointed out. (Author in part)

REVIEW: This is a very brief paper, but it constitutes a clear and concise description which accomplishes its purpose. It is a further contribution to the collection of experience in the use of infrared techniques as a reliability tool. ##

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Serial Number 2128 -1
ASQC Codes 775;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Infrared nondestructive testing for improvement of integral electronic circuits

AUTHORS: H. S. Kleiman and J. D. Reese, ARINC Research Corporation, Washington, D. C.

SOURCE: 19 pp., presented at the 3rd Annual Meeting of the Infrared Techniques for Electronics Committee, Huntsville, Alabama, February, 1964 (Proceedings published by The Society for Nondestructive Testing, Inc., 914 Chicago Avenue, Evanston, Illinois, October, 1964)

PURPOSE: To describe the role of infrared testing techniques in the improvement of integral electronic circuits.

ABSTRACT: The term "integral electronics" (IE) is used to refer to the following two types of circuits: the semiconductor functional block and the thin--film circuit. These are attaining increased importance wherever a high premium is placed on reliability, weight, volume, or power consumption, particularly in aerospace applications. Present testing techniques are not adequate for IE, since they cannot produce the information needed to meet the rigorous demands of reliability and quality control. In IE circuits a complete understanding of circuit thermal behavior is especially critical. For this reason, infrared testing techniques have distinct advantages.

However, it is not only the consideration of heat as a trouble area that makes infrared testing so attractive. Infrared testing is of special interest as an indicator of failure mechanisms other than those associated directly with temperature. It has significant potential for integral electronics in several modes that are not applicable to discrete electronic components. The need for new IE test techniques is based on the following considerations: (1) high reliability, (2) level of testing, (3) physical contact, (4) high-density packaging, and (5) heat. These considerations are discussed separately. It is indicated that infrared testing is the most promising approach for application to IE components, but that other techniques which might complement it are also being investigated.

The advantages of infrared testing include: (1) No physical contact - The existing radiation of a "hot" circuit serves as the source of infrared energy. (2) Direct heat measurement - With heat sensed directly and temperature sensed indirectly, measurements should be faster, cheaper, and more meaningful. (3) High speed - Information can be obtained in milliseconds, and in microseconds with photodetectors.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

These are essential for IE components, whereas they are merely desirable for discrete parts. If for nothing else, the method would be justified for its "no physical contact" characteristic; in addition, the speed factor is indispensable for scanning large-scale production quantities. Other important advantages of infrared testing are (a) monitoring of all components, (b) automation potential, and (c) use of unskilled or semiskilled labor.

The second part of the paper broadly views actual IE components and available radiometers and then quantitatively confirms the essentials of the theoretical premises. Can a contemporary radiometer sense radiant-energy levels from a typical energized IE circuit? This is a basic prerequisite. By a rather crude analysis, the practicality of the technique is verified. No attempt is made to interpret the implications of various heat levels. (Authors in part)

REVIEW: This paper does a good job of describing the role of infrared techniques in the testing of integral electronic circuits. The section on quantitative analysis of infrared testing for integral electronics makes it quite clear that much work remains to be done before acceptance/rejection criteria can be determined on the basis of absolute measurements. Work toward the goal of obtaining quality-control and reliability criteria without prolonged testing and at dollar savings should prove to be extremely valuable. ##

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Serial Number 2129 -1
ASQC Codes 775;835;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The Thermal Plotter and its uses in microcircuit analysis and testing

AUTHORS: B. G. Marks, G. Revesz and M. Walker, Philco Corporation, Lansdale Division, Lansdale, Pennsylvania

SOURCE: 23 pp., presented at the 3rd Annual Meeting of the Infrared Techniques for Electronics Committee, Huntsville, Alabama, February, 1964 (Proceedings published by The Society for Nondestructive Testing, Inc., 914 Chicago Avenue, Evanston, Illinois, October, 1964)

PURPOSE: To describe and analyze an instrument for measuring the radiated energy of small structures, to investigate various methods of using it in conjunction with information-display systems, and to report on its use on a variety of structures.

ABSTRACT: In the usual method for analyzing an electrical circuit, the circuit's gain is first established and then its transient response is investigated by means of Laplace transforms. It is shown in this paper that the same methods can be usefully adapted to analyze optical systems. In this context the gain is equivalent to the system sensitivity, and the frequency response is equivalent to the system resolution. By this method the optical transfer function of the Thermal Plotter is derived.

In investigating the methods of displaying the information gained by the Thermal Plotter, various methods of scanning are presented. These methods range from a simple point-by-point measurement by means of a micrometer substage to high-speed scanning and display on a cathode ray tube screen. The relative merits of these display systems are discussed.

By using the Thermal Plotter in combination with suitable microcircuit scanning techniques, the authors have endeavored to obtain accurate thermal profiles on both silicon and film type microcircuits. The main difficulty was the emissivity variation due to the number of different materials and different forms of materials present on microcircuit assemblies.

Among the results obtained are the following:

(a) Indications of consistently greater temperature variations on film circuits than on integrated silicon circuits,

(b) Thermal resistance curves of "hot spots" on both film and integrated silicon circuits have been plotted for a rapid indication of power dissipation characteristics of typical microcircuits in two forms of flat packaging, and

(c) Indications of feasibility of correlating "hot spot" temperatures with operating life test results. This points to

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

the use of the Thermal Plotter in the area of reliability prediction. (Authors in part)

REVIEW: This is a good discussion in reasonable detail of the nature and use of an infrared sensing device used to analyze the temperature distribution of such structures as microcircuits. Three references are cited for those who may desire more information. The use of this device as a reliability tool will depend on the ability to correlate the temperature data with the operating life characteristics of the circuits. Prospects for doing this look promising.

The first author, in a private communication, has indicated that they have done further work in the area of reliability, and has cited a more recent paper [1]. This paper, available from the author, will be of interest to those concerned with the determination of the thermal resistance of microelectronic devices. The operation and calibration of the Thermal Plotter are described. Its application to thin film resistors, thin film inverters, non-dissipating components, a three input gate, and a dual three input gate are illustrated.

REFERENCE: [1] "Application of isothermal mapping as a reliability tool," by W. M. Berger, Philco Corporation, Lansdale Division, Subsidiary of Ford Motor Company, Lansdale, Pennsylvania

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64N23414

Serial Number 2130
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Problem of dependability of electric motors

AUTHOR: N. A. Tishchenko

SOURCE: Russian Periodical, Elektrichestvo, Nr. 11, 1961, pp. 7-14, Translation prepared by Translation Division, Foreign Technology Division, WP-AFB, Ohio, FTD-TT-63-35/1 + 2, 12 March 1963 (DDC AD No. 402437; NASA accession number N64-23414)

PURPOSE: To discuss the problem of electric motor breakdown--the causes and cures.

ABSTRACT: In some industries as many as half the motors are repaired each year. On the average, 20% are repaired each year. Large and small motors differ as to their reasons for failure. Stator windings are a major culprit; bearings are quite good. One of the main reasons for poor life is that manufacturers strive for low first cost, not low total cost of owning the motor. Laboratory tests do not correspond well with field experience--they are too mild. The insulation breakdown in motors is due to the high temperature rises in some of them, especially the enclosed variety --even though their insulation is better. Motors should be designed with adequate safety margins to allow for bad service conditions.

If motors are more efficient, their temperature rise is less and they consume less power. The extra power that inefficient motors consume is multiplied several times by other losses in the distribution system. More efficient motors can save many times their extra cost since electricity is rather expensive. (Some data are given substantiating the conclusions.)

REVIEW: There is little in this report for American readers except a glimpse of what is going on in Russia. The copy is fairly readable and the translation is not too bad. One interesting point is that they seem to be complaining about the same kinds of erroneous thinking as we are. ##

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64N23415

Serial Number 2131
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Problem of reliability of electric motors

AUTHOR: N. A. Tishchenko

SOURCE: Russian Periodical, Elektrichestvo, Nr. 12, 1961, pp. 16-19, Translation prepared by Translation Division, Foreign Technology Division, WP-AFB, Ohio, FTD-TT-63-36/1 + 2, 18 March 1963 (DDC AD No. 402441; NASA accession number N64-23415)

PURPOSE: To discuss the reliability and performance of electric motors in the USSR.

ABSTRACT: The costs of owning, operating, and maintaining motors are considered. Motors with present ratings should be conservatively applied with regard to operation temperatures. New motors should be designed with longer-life insulation. Service factors are important and should not be overlooked. Parameters such as starting currents, steel and copper losses should be considered. The number of starts per unit time is important. Some data on the supply of motors in the USSR are given.

REVIEW: The translation is abominable. The technical information is well known in this country, if not always practiced. The paper is useful for getting an idea of Russian problems and progress. ##

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Serial Number 2132
ASQC Codes 422;822

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Various properties of the Poisson distribution

AUTHORS: G. F. Hadley, University of Chicago and T. M. Whitin, University of California, Berkeley

SOURCE: P-2421, The RAND Corporation, August 25, 1961 (DDC AD No. 606097)

PURPOSE: To present a listing of mathematical properties of the Poisson variable.

ABSTRACT: A list of properties of the Poisson variable is presented. The relationships are useful in working with a variety of operational models. In particular the properties have proved useful in obtaining explicit expressions for inventory levels, backorders, and stockout costs under various assumptions concerning the lead time distribution and penalty functions. Some of the relationships are almost immediately obvious; but they are included in this paper for the sake of completeness. There are 81 such equations listed. (Authors in part)

REVIEW: Since the Poisson distribution is used so often in reliability-maintainability studies, this list may prove quite useful. No attempt was made to check the mathematics. ##

8/65

64N 31350

Serial Number 2133
ASQC Code 782

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Eurospace Memoranda--Reliability

AUTHOR: --

SOURCE: NASA accession number N64-31350, June, 1964

PURPOSE: To develop and amplify the ideas contained in the 1963 edition of "Proposals for a European Space Program."

ABSTRACT: The material is tabulated under

I. Environmental conditions encountered from manufacture through orbit of a space vehicle.

II. Special environments liable to be encountered by the equipment in the satellites recommended by Eurospace.

III. Classification of the equipment and definition of the environmental tests required.

REVIEW: This is a long tabulation of data. It was not checked for suitability or accuracy. Those involved in specifying this type of data will find this document of interest. ##

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 64N10698

Serial Number 2134
ASQC Code 838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability of redundant apparatus

AUTHORS: A. L. Garkavi and V. B. Gogolevskiy

SOURCE: Translated from the Russian-language periodical Izvestiya Akademii Nauk SSSR, OTR, Energetika i Avtomatika (NASA accession number N64-10698)

PURPOSE: To analyze different kinds of redundant systems.

ABSTRACT: The analysis considers n identical items in a system which works as long as one item works. The following cases are considered:

1. All items are connected; no repairs are made.
2. Item k is connected only when item (k-1) fails; no repairs are made.
3. Only one item operates; the others are in reserve or are being repaired. Failures are Poisson.
4. All are connected initially. A failed item is disconnected, repaired and reconnected.
5. "Two items double each other, being constantly in a working state. Errors are eliminated during the on state; the occurrence of new errors in a repair item is possible."

Several assumptions are made about repair times in the analyses.

REVIEW: These models are reasonably well treated in the American literature, so that except as an example of Russian work, this paper will be of little use. The copy is not too easy to read and in some cases the translation is not clear--as in case 5 in the above abstract. ##

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Serial Number 2135
ASQC Code 838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Calculation of the reliability of radio systems with element reserving

AUTHOR: G. G. Men'shikov

SOURCE: Telecommunications & Radio Engineering, Part II, December 1963, TKL-T34, pp. 68-72

PURPOSE: To calculate the MTBF of groups of parallel redundant items for several groups in series.

ABSTRACT: Given the following assumptions, the MTBF of the system can be calculated:

1. There are m + 1 identical elements logically in parallel redundancy in each group.
2. The system has n identical groups logically in series.
3. Each element has Poisson behavior with MTBF "T".
4. The system works as long as one element in each group works. The failure of an element removes it from the system.

Then $$\mathrm{MTBF}_{\text{system}} = \frac{(n-1)!}{m+1}\, T \sum_{p=0}^{m} \frac{\Gamma\left(\frac{p+1}{m+1}\right)}{\Gamma\left(\frac{p+1}{m+1} + n\right)}$$

REVIEW: This paper is on the subject treated in the American literature as identical items in identical parallel groups with the groups in series. This is a special case of the series-parallel, parallel-series treatments which are well covered in the American literature. It should be noted that for mission times short compared to the item life, failure rate is a more useful term than mean life. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Post-irradiation reliability of transistors

AUTHORS: L. B. Gardner, Consulting Scientists, North Hollywood, California (formerly with Northrop Space Laboratories) and J. R. Coss, Northrop Space Laboratories, Hawthorne, California

SOURCE: 7 pp., presented at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Canada, June, 1963 (IEEE Conference Paper CP63-1057)

PURPOSE: To summarize the results of a life test of transistors which had been exposed to neutron radiation.

ABSTRACT: The results of a post-irradiation life-test of selected transistors is presented. These devices were exposed to steady state mixed neutron and gamma radiation of approximately $3.3 \times 10^{13} nv_e t$. A similar group of transistors were kept as controls. They were life-tested but not exposed to radiation. The results of the test show post-irradiation annealing of certain transistor parameters and the permanent radiation damage of other parameters. They also show the important role played by manufacturing processes with respect to the observed radiation damage and the annealing thereof. There is a statistically significant indication to show that one of the transistor types tested is failing. This was not, however, observed in the other type of transistor test, despite the fact that the silicon chips of both types were identically manufactured. The significance of this observation is discussed. (Authors)

REVIEW: This is the final paper in a series, earlier items in which included those covered by RATR 255, 617, 787, 821, and 1175. The experiment is adequately described and the discussion of the results is quite informative.

TITLE: Transistor reliability after radiation exposure

AUTHOR: Leonard B. Gardner, Northrop Space Laboratories, Hawthorne, California

SOURCE: 6 pp., presented at the Fourth National Winter Convention on Military Electronics, Los Angeles, California, January 30 - February 1, 1963

This is quite similar to the paper covered by RATR 1175, except that data on a few other transistors are included. ##

64N80217

Serial Number 2137
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Handbook for the prediction of shipboard and shore electronic equipment reliability

AUTHOR: R. G. Stokes, Vitro Laboratories, Silver Spring, Maryland

SOURCE: Navships 93820, Technical Report 133, Contract NObsr 77519, April 1961, Vitro Laboratories, Silver Spring, Maryland (DDC AD No. 425141)

PURPOSE: To present a handbook for calculating failure rates of electronic equipment.

ABSTRACT: A handbook is presented which provides methods for predicting the reliability of electronic equipment. Several methods are demonstrated, each to be used for a specific phase in the evolution of a design from initial rough concept to final detailed design disclosure. All methods presented are based on the same mathematical concept, differing only in the degree of detail required in the prediction. Such an approach permits a rough reliability estimate based on the class of equipment, or a slightly better estimate based on the number of active elements, or an even better estimate based on the actual number of parts of all categories included in the design, or a best estimate based on the number of parts and their severity of application. A rough estimate may be made in a few minutes, but the best estimate may require weeks of analysis.

In addition to the prediction procedures, failure rate data are provided for classes of equipments, classes of parts, and individual parts such as electron tubes. Without such failure rate data, quantitative reliability prediction is impossible. In order to allow the user to estimate the confidence that may be placed in the stated rates, an appendix provides source and quantity information used to calculate the failure rates. No procedure is included for measurement of reliability by equipment testing. (Author in part)

REVIEW: While the date on this document is April 1961, it was just recently indexed in DDC's Technical Abstracts Bulletin. The handbook is similar in nature and intent to that of the RADC handbooks. These can serve a good purpose if the user is aware of the engineering limitations on such calculations. To blindly put exorbitant amounts of faith in the last decimal place of the calculations is obviously foolish. However, to never use these tools because they are not exact would be equally foolish.

The author in a private communication has pointed out that this document has been updated twice since its original publication, and that a further revision is due to appear shortly. ##

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8/65

64N22415

Serial Number 2138
ASQC Codes 716;782

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Corrosion fatigue properties of structural materials

AUTHOR: R. J. Heitzmann, Engineering Materials Group, Structures Section, Grumman Aircraft Engineering Corporation, Bethpage, New York

SOURCE: Report No. ADR 02-09-62.1, 34 pp., January, 1963 (Progress Report) and Report No. ADR 02-09-64.1, 20 pp., February 1964 (Final Report), Grumman Aircraft Engineering Corporation Advanced Development Program (Final Report: NASA accession number N64-22415)

PURPOSE: To present a realistic comparison of material performance in a sea water environment and to furnish reliable corrosion fatigue data for design purposes.

ABSTRACT: The corrosion fatigue properties of 5456 Al plate, SAE 4130 steel plate, Inconel 718 plate, Superston 40, Superston 60, K-monel, titanium 6Al-4V, cast 4330 steel, and cast 420 modified corrosion-resistant steel are reported. Pertinent material data and static tensile properties are also included, except for Inconel 718. The specimens (all flat except for round titanium specimens) were exposed for seven days in sea water without external loading. Following the precorrosion sea water exposure, the specimens were axially fatigue tested at 1800 cpm (generally at $R = +0.05$) in a continuously circulated 3 gal./min sea water environment. Smooth, notched, and butt welded specimens were tested in some cases. Protective coatings--vinyl anti-fouling paint for 5456 Al and epoxy-polyurethane paint for 4130 and cast 4330 steel--were evaluated. Some tests were conducted with the protective coatings damaged by scribe marks. Certain data available from the literature are also included. Corrosion fatigue efficiency curves and fatigue strength-to-weight ratios for the alloys in the range of 2×10^5 to 3×10^7 cycles are presented along with S-N curves. Titanium 6Al-4V and Inconel 718, based on strength-to-weight, are the most efficient alloys. Al 5456 and 4130 steel demonstrate high fatigue strength-to-weight ratios when protected by a sound paint or other protective coatings. Stress-relieving of weldments in 5456 Al alloy is detrimental to corrosion fatigue strength. Superston 40 is recommended for low-cost, easily repaired marine applications; but Superston 60 is inferior to Superston 40. Cast 420 modified steel is not recommended for structural applications because of its poor fatigue strength-to-weight ratio and its high susceptibility to oxygen concentration cell corrosion.

REVIEW: These reports cover a four-year testing program. The fatigue curves reported were drawn by "eye estimates" through minimum points. In general the reports are informative; but the fatigue curves are useful only as first-order approximations because of the limited data and the absence of statistical analysis. ##

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G

Serial Number 2139 -1
ASQC Codes 712;716;851

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Tuned Q analysis of fatigue damage

AUTHOR: I. G. Hendrickson, Boeing Company, Seattle, Washington

SOURCE: Beoing Document No. D2-35141, 28 pp., 23 April, 1964, Boeing Company, Seattle, Washington (DDC AD No. 444413)
but see 62N17714

PURPOSE: To demonstrate the merits and feasibility of the mechanical Q analysis for fatigue monitoring and fatigue damage analysis.

ABSTRACT: A fatigue damage parameter, mechanical Q, was measured for flat 1/10 to 1/8 inch thick specimens of 4340, 17-7PH and AM355 steels; and 2024-T3, 2219-T6, 7075-T6, 7178-T6, bare and alclad aluminum alloys. The Q values were measured by the unrestrained torsional mode of vibration to evaluate the role and relation of surface to bulk shear stress properties. The specimens were fatigued at 1800 cpm in tension-tension at a stress ratio of 0.06 in a normal room temperature environment. The maximum applied load ranged from below 60% of the ultimate tensile strength to above the yield strength for the various materials.

Bare 4340 surface ground steel and bare 7075-T6 aluminum had high Q's which were maintained until shortly before failure. Surface oxidized 4340 steel and alclad 7075-T6 aluminum demonstrated high rates of decrease in Q as a function of fatigue cycles, resulting in low Q as failure is approached. Overaged 17-7PH steel had low initial Q and a relatively small overall decrease in Q during its fatigue life. A three-stage progression sequence was observed for these fatigue damage patterns. Surface conditions--oxidation, alclading, shot peening, and electrolytic hydrogen charging--had a large effect on the Q fatigue damage patterns of the materials tested. The magnitude of the decrease in Q for many of the bare steels and aluminum alloys was found to be independent, or nearly so, of the applied stress. In contrast, the magnitude and/or rate of decrease in Q during the second stage of fatigue damage for the alclad aluminum alloys was found to be highly dependent on the applied stress. A significant difference in the recovery of Q was observed for the bare materials as compared to the coated or oxidized materials. The observed decreases of Q with fatigue cycles can be indirectly related to accumulated plastic strain occurring during fatigue under certain surface conditions. There is considerable evidence that fatigue cracks are initiated early in the material's fatigue life. The Q fatigue damage curves for surface oxidized steels demonstrate the three stages of fatigue damage: (1) crack initiation, (2) subcritical size crack growth, and (3) rapid crack growth and catastrophic failure. The Q analysis data demonstrate the important effect of material surface conditions on fatigue life.

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Serial Number 2139 -2
ASQC Codes 712;716;851

RELIABILITY ABSTRACTS
AND TECHNICAL REVIEWS

REVIEW: This paper is not for the beginner; and unless one understands the Q fatigue damage parameter, it is difficult to read because of the subject matter. The scientist who is endeavoring to better understand fatigue phenomena will find the paper useful, although it would be of little use to the design engineer.

The author has included a thorough analysis and discussion of all results, including contradictory results. Since only one set of data points is presented for each condition, the work must be considered as exploratory.

A Boeing proprietary document, listed as the first reference to the paper, is perhaps important to a complete understanding of the paper. ##

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6

Serial Number 2140
ASQC Code 813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A reliability study of diesel engines

AUTHOR: W. J. Lux, Caterpillar Tractor Company

SOURCE: 9 pp., presented at the Earthmoving Industry Conference, Central Illinois Section, Peoria, Illinois, April 14-15, 1964, Society of Automotive Engineers paper S374

PURPOSE: To highlight some reliability problems and efforts.

ABSTRACT: A study of diesel engine experience showed that there is a period of infant mortality, followed by a period of constant failure rate, and then by a period of wearout. A formal reliability program is essential to get rid of the early failures which are largely "foolish" ones and to reduce the failure rate during the constant period to an acceptable value. The elements of such a program are outlined.

REVIEW: This is an introductory paper which can give a feeling for the subject of reliability, but conveys no quantitative information. As such it is suitable for beginners and for management levels that require little technical detail. The comments on failures induced by servicing are good. There is a conceptual difficulty with Poisson behavior; many people do not seem to relate it to the "exponential distribution" of times-to-failure (the one actually implies the other). In the exponential distribution, short failure times are quite common; long ones are relatively rare. For example, almost 2/3 of the units will fail before the mean time-to-failure. If the MTBF is 10^4 hr (as in a text example) for the ten engines starting the test, at least six are expected to fail before the 1000 hr clock time is over. Another mistake which is often made is that of labelling the common area under the stress and strength curves as the probability of failure.

The author puts much emphasis on the design department; in truth, all departments are necessary, and no one alone is sufficient.

All in all, if one just gets a "feeling" from the article, it serves a good purpose. It should not be used for more than that.
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8/65 G

Serial Number 2141
ASQC Codes 711;770;813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Stress analysis and life testing of brake and suspension components

AUTHOR: Robert P. Keller, Engineering Staff, Chrysler Corporation

SOURCE: 8 pp., presented at the Automobile Week, Detroit, Michigan, March 30 - April 3, 1964, Society of Automotive Engineers paper 825A

PURPOSE: To describe some methods of stress analysis and service load evaluation.

ABSTRACT: Product design, production and service, and test and development are three essential parts of a reliability program. This paper deals with the last part. Brittle lacquer and strain gages are two popular methods of stress analysis. For laboratory work to be effective, the service loads--dynamic as well as static--must be known. Life tests can be run on designs which have passed the screening tests. These will usually be for fatigue endurance. Some additional important points in any program are:

1. Perform nondestructive tests early in the program to provide for correction of areas of weakness before embarking on lengthy proof tests of a finished design.
2. Do not disregard the unexpected or apparently abnormal test results because they often prove to be clues to a problem solution.
3. Use the most accurate material properties available, preferably from tests on production parts, being cautious with handbook data for which complete test history is not included. (Author in part)

REVIEW: This is a qualitative paper which does a good job of introducing the names and characteristics of stress analysis and life test methods. It is suitable for management or others who want to get a general impression as to what some of these words and ideas mean. ##

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Serial Number 2142 -1
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Investigation of causes for high failure rate of transitorized airborne equipment

AUTHOR: (Compiled by E. de Vry, Flying Officer, Project Engineer)

SOURCE: Report No. 1597, 60 pp., Royal Canadian Air Force Central Experimental and Proving Establishment, October, 1961 (DDC AD No. 269960)

PURPOSE: To describe an investigation of the causes of failures of transistorized airborne equipment and to recommend remedial measures.

ABSTRACT: This report describes an investigation to determine the cause of repeated failures in two transistorized airborne equipments. The airborne equipments involved were the Andrea A-81 intercom system and the VOR/ILS navigation system aboard the Dakota (C47) and the Cosmopolitan (CC109) aircraft.

In particular, the investigation was limited to observing and recording transients on the dc power bus during all phases of equipment operation, i.e., ground operation with auxiliary power units, engine starts, equipment turn-on, during flight and during routine ground crew operation. Significant conclusions were that

1. Negative-going transients on the dc power bus were a likely cause of the frequent failures.
2. The ground generators (auxiliary power units) were poorly regulated and, consequently, contributed greatly to the undesirable transient conditions.
3. Ground crew procedures contributed to the equipment failures by permitting the application of poorly-regulated voltages to the aircraft.
4. No significant transients were present when the aircraft was operated from its internal power supply.

It was recommended that:

1. Suitable protective circuitry be obtained and installed to protect the A-81 Intercom and VOR/ILS equipments against transients.
2. The equipments involved be isolated from other loads in the aircraft during ground runs.
3. The groundcrew and aircrew be briefed on the occurrence of transients and directed to ensure that the ground generator is set at the correct voltage in order to minimize the transient amplitudes.
4. The voltage regulators in the ground generators be investigated and suitable modifications be incorporated, if feasible, to improve their regulation. (Author in part)

REVIEW: The investigation described in this report was a reasonable

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RELIABILITY ABSTRACTS
AND TECHNICAL REVIEWS

engineering procedure to determine the cause of failures in airborne equipment. The study of the problem was certainly not complete, but the limited investigation was justified by the positive results obtained from the consideration of the dc power bus transients. This was obviously the most likely beginning point. The report is well written and complete. From a reliability point of view, it would have been worthwhile to discuss the role of specifications in achieving reliable systems. Meaningful specifications descriptive of transients on the dc power bus and auxiliary power units meeting those specifications would have eliminated the need for this study. ##

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Serial Number 2143 -1
ASQC Codes 711;712;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

Fracture toughness and fracture mechanics
(A set of four papers)

SOURCE: Materials Research & Standards, vol. 4, pp. 103-134, March, 1964

...

TITLE: Assault on fracture pays off (pp. 103-106)

AUTHOR: A. Q. Mowbray, Editor, Materials Research & Standards

...

TITLE: Progress in measuring fracture toughness and using fracture mechanics--fifth report of a special ASTM committee (pp. 107-119) 64A16099

AUTHOR: --

... 64A16100

TITLE: Acoustic detection of crack initiation in sharply notched specimens (pp. 120-129)

AUTHORS: M. H. Jones and W. F. Brown, Jr., Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio

...

TITLE: Measuring fracture toughness of adhesive joints 64A16101

AUTHORS: E. J. Ripling, S. Mostovoy, Materials Research Laboratory, Richton Park, Illinois, and R. L. Patrick, Alpha R and D Inc., Blue Island, Illinois (pp. 129-134)

...

PURPOSE: To provide a summary of ASTM work in fracture testing and to present two papers on fracture mechanics.

ABSTRACT: High strength materials may fracture in a brittle way. This usually occurs at a notch of some kind and at a low nominal stress. The high-strength materials tend to be rather susceptible to this type of failure. The propagation of cracks, a measure of fracture toughness, and specimen design have all been studied.

The ASTM Special Committee on Fracture Testing of High-Strength Materials has provided a focal point for interest, talent, and information in the field of fracture; enforced decisions in national aerospace programs which might not otherwise have been made; created widespread appreciation of the need for sharp-notch tests in materials evaluation programs; and evolved a rational approach to the analysis of fracture. This article gives a brief history of the committee's work and describes its present and future programs.

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Serial Number 2143 -2
ASQC Codes 711;712;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

Crack propagation mechanisms are reviewed and test methods are discussed. Recommendations for improving test methods include assuring adequate notch sharpness by fatigue-crack extension of the notch, if necessary, using compliance gages and photography to measure slow crack growth, and using specimens of sufficient size to assure that fracture will occur prior to general yielding. Equations are given for predicting critical crack lengths and flaw sizes, and the prediction of pressure vessel failure mode is discussed. The prediction of the service life of structures is also discussed, and the value of proof tests is pointed out. A curve is presented showing how minimum service life can be predicted from a proof test.

Crack initiation in high-strength alloys is accompanied by an audible pop. An ordinary phonograph pickup and a two-channel tape recorder record fracture sounds and load simultaneously. The recordings can be studied by listening to a play-back of the tape or by making an oscillographic record. Results are given for H-11 modified steel, 300M steel, and 7075-T6 aluminum alloy. The fracture of the aluminum specimens was simultaneously measured with a compliance gage, and the acoustic method of crack detection was found to be more sensitive.

Techniques are described for measuring the fracture toughness of adhesive joints for both an opening mode and a forward shearing mode of fracture. Specimen design and the effect of modifications in geometry are discussed. A stiff testing machine that gives excellent control over crack growth is also described. A nomogram is included in the report for determining opening mode and crack length from compliance and critical load for crack propagation. The measurement of forward shearing mode is also discussed and the much simpler equations for its determination are given as well as test data comparing opening mode and forward shearing mode.

REVIEW: The technical papers in this issue are all devoted to fracture toughness. This property of materials is related to a serious mode of failure if for no other reason than many design engineers' not being familiar with it. The two introductory articles are valuable both for their historical discussion and for technical material. The other two are also good, but, of course, are more specific. For those not acquainted with the problem, this issue provides an especially valuable introduction (it is also valuable to the "old timers" in the field). ##

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6

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

Three papers on reliability presented at the British IRE Symposium on "Cold Cathode Tubes and their Applications," University of Cambridge, England, March, 1964 (The Institution of Electronic and Radio Engineers, 8-9 Bedford Square, London W.C.1, England)

...

TITLE: Component tolerances as a governing factor in the success of cold cathode tube circuit design

AUTHOR: D. M. Neale, Research Department, Ilford Limited

6

...

TITLE: Counting circuit design using the inherent reliability of counting tubes

6

AUTHORS: C. S. Barker and G. F. Jeynes, Mullard Limited

...

TITLE: The trigger tube--reliability and ratings

6

AUTHOR: M. E. Bond, Mullard Limited

...

PURPOSE: To provide information for the design of reliable circuits using cold cathode discharge tubes, especially stepping tubes.

ABSTRACT: Cold cathode tube circuits are more sensitive to circuit variations and tube variations than are circuits with hot cathodes and the usual types of implicit negative feedback. Methods are given for designing a variety of circuits so that tube life itself is maximized and circuit life is also maximized by proper attention to component tolerances. For stepping tubes the important factors are (1) negative guide voltage to step the discharge from a main cathode to the guide A and B cathodes, (2) positive guide voltage to transfer the discharge from the guide B to the next main cathode, (3) derivation of a main cathode voltage output signal, and (4) the anode current range. There are optimum values for each of these factors with regard to adequate performance for a long life. (Authors in part)

REVIEW: While the data in these papers refer to several specific tube types, the principles have general application. Designers of cold cathode tube circuits should be familiar with the essence of these papers. The comments on tolerances are quite pertinent. ##

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63N86334

Serial Number 2145
ASQC Codes 090;711;782

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Thermoelectric generators and materials: radiation effects, reliability, lifetime, and failure--an annotated bibliography

AUTHOR: (Compiled by E. Graziano)

SOURCE: Special Bibliography SB-61-60, 40 pp., January, 1962, Lockheed Missiles and Space Division, Lockheed Aircraft Corporation, Sunnyvale, California (DDC AD No. 273953)

PURPOSE: To provide selected references on factors affecting the life of thermoelectric generators.

ABSTRACT: This literature search was conducted as part of research on the problems of using thermoelectric generators in space, which would directly convert heat from nuclear sources into electricity. The purpose was to bring to light any information regarding reliability, lifetime, and mean time to failure of thermoelectric generators and materials due to oxidation, cracking, galvanic action, short circuits, radiation effects, and sublimation.

The results of the search indicate that almost nothing exists in the technical literature concerning lifetime and reliability of thermoelectric generators; for this reason, the scope of the bibliography was broadened considerably to include selected references to other thermoelectric devices and material when any mention was made of factors that might cause failure or malfunction. A brief abstract is provided for each entry. The 88 entries are arranged in alphabetical order by author. There is no subject index. The near-cut-off date is 1961. (Author in part)

REVIEW: The author searched many indexes, one going back as far as the 1930's, but most of them are since 1950. The lack of a subject index may not be serious since there are so few items. ##

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8/65 64 N18012 Serial Number 2146
ASQC Codes 090;838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Bibliography on the use of redundancy as a means of improving reliability

AUTHORS: J. G. Mead and R. J. Thompson, Statistical and Mathematical Analysis Section, Reliability Department, Aerospace Corporation, El Segundo, California

SOURCE: Report No. TDR-269(4303)-6, 28 pp., prepared by Aerospace Corporation for Commander Space Systems Division, USAF, Inglewood, California (Contract No. AF 04(695)-269), 15 January, 1964 (DDC AD No. 433614; NASA accession number N64-18012)

PURPOSE: To provide a bibliography on redundancy and reliability.

ABSTRACT: About 250-300 articles are listed in alphabetical order by author. The near-cut-off date is about December 1963. No abstracts are given. There is no subject index.

REVIEW: In general, one has to go through the list each time it is used unless the author's name is known. This tends to reduce the utility of the bibliography, but at the same time a useful indexing within the field of redundancy would not be easy to achieve.

Another bibliography on redundancy is [1].

REFERENCE: [1] Circuit design reliability through redundancy (A literature survey of unclassified reports), compiled by James R. Trew, STL Bibliography No. 38, 15 August 1960, Space Technology Laboratories, Inc., Post Office Box 95001, Los Angeles 45, California (DDC AD No. 607549) ##

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64N29266

Serial Number 2147
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Dynamic models for low cycle fatigue

AUTHORS: W. H. Roberts and K. Walker, Northrop Corporation

SOURCE: RTD-TDR-63-4197, Part I, 39 pp. (NASA accession number N64-29266)

PURPOSE: To evaluate the use of a dynamic model for predicting fatigue behavior of simple and complex structures.

ABSTRACT: The need for a new technique in making an analysis of the various complexities of fatigue in service structures is satisfied with the use of a dynamic model. This technique employs the use of a scaled model of the full-size complex structure. The lessened requirement for full-scale test facilities and the reduction of testing expense allows establishing structural qualification during the design period. The techniques are illustrated by the use of models in panel and complex structure tests. Acoustic fatigue tests performed on simple scaled panels produced consistent expected failure life between full scale and models of 1/3 and 1/6 full scale. Experience has shown that fatigue crack propagation does not scale since the stress loads remain the same at corresponding points in scale and full-size structures. Cracks are found to progress at the same rate in scaled and full-size structures, resulting in earlier failure for the models.

Limited success was obtained in tests involving the scaling of the vibro-acoustic response of a complex structure. The accuracy obtained between transfer functions in model and full-scale structure as induced using an air modulator for input was 6 db standard deviation. This accuracy can be improved to 1 or 2 db if the model is made without compromise to cost. Besides providing fatigue information, the model is capable of: (1) shortening the design period, (2) qualifying the structure for combined loading, and (3) shortening testing time by approximately the scale factor. The greatest model limitation is that failure time is not predicted from the S-N curve. Early failure times are due in part to the fact that the crack propagation does not change substantially in the model and to such parameters as stress gradient, creep, corrosion, and temperature effects for which scaling relationships are not known.

REVIEW: The use of scale models appears to be beneficial from the standpoint of reducing testing time and cost. It appears, however, that this work leaves many questions unanswered. Little evidence of successful fatigue application is given and serious limitations exist from the standpoint of accurately simulating structures and environmental conditions. It appears that the use of this method now for complex structures leaves much to be desired. ##

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64N21441

Serial Number 2148 -1
ASQC Codes 711;775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Nondestructive evaluation of metal fatigue

AUTHORS: Felix N. Kusenberger, John R. Barton, and W. Lyle Donaldson, Department of Electronics and Electrical Engineering, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas 78206

SOURCE: AFOSR Final Scientific Report 64-0668, 71 pp., prepared for AF Office of Scientific Research of the Office of Aerospace Research under Contract AF49(638)-1147, by Southwest Research Institute, 13 March 1964 (DDC AD No. 600277)

PURPOSE: To investigate the relationship between magnetic signal changes and localized stress buildup in a specimen subjected to dynamic loading.

ABSTRACT: Magnetic nondestructive inspection techniques have been developed which can detect localized residual stresses, inclusions, voids, and microcracks in ferromagnetic materials. Very small perturbations in a uniform magnetic field are caused by permeability variations within the item and are detected. This technique has a high degree of sensitivity and repeatability.

The inspection method was originally developed for analysis of cylindrical specimens but is being adapted to necked rod specimens because they are more widely used and because of the wealth of existing fatigue data available on them. The report describes in detail the results obtained from stress-cycle tests on 14 rod-type specimens. Seven of these specimens were stress-cycled in axial tension for determination of stress which would result in a mean life of 1 to 2 million cycles. Magnetic inspection data were obtained on the remaining seven specimens which were tested at the established conditions and, of these, four had magnetic signal changes. These signal changes were correlated with minute 6 to 8 mil long surface fatigue cracks observed at a "warning time" before complete failure occurred; 23% of the specimen life remained after the initial signal change was obtained.

The magnetic inspection equipment consists mainly of specimen magnetizing coils, a probe for detecting variations in the magnetic field, and a scanning mechanism for moving the probe in an arc along the axis of the specimen. The Hall effect probe used in this work is unique in that it does not depend on a relative velocity between the specimen and probe in order to generate a signal. Previous work was performed on cylindrical specimens which were rotated at high velocities in the magnetic field.

REVIEW: This paper clearly presents a new and useful technique for nondestructive evaluation of ferromagnetic materials. Each of

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the tests is discussed in detail and particular signal shapes, graphs, and photos of failure surfaces are presented. The amount of "warning time" between a detectable signal and complete fracture is influenced by a large number of factors such as type of load, method of loading, load spectrum and specimen geometry. All of these factors with their influence on "warning time" could be significant when comparing laboratory test results with results obtained from actual field loading conditions. It was found in this work that a specimen which had incurred fatigue damage from constant amplitude stressing had incurred no further damage after 280,000 cycles of programmed load.

The scanning process is not continuous and the intervals between scannings must be short to obtain signal changes at a sufficient "warning time" before complete failure occurs. In complex parts containing a large number of notches and where the region of failure cannot be predicted with confidence, the scanning mechanism becomes very complex and the scanning time is increased considerably. ##

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8/65

64N29760

Serial Number 2149
ASQC Codes 711;712;770

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Tensile test to find endurance limit of strain-ageable metals

AUTHORS: Knud Pedersen and Glenn Murphy, Ames Laboratory, Iowa State University of Science and Technology

SOURCE: United States Atomic Energy Commission Research and Development Report IS-929, 18 pp., July, 1964, Ames Laboratory, Iowa State University of Science and Technology (NASA Accession number N64-29760)

PURPOSE: To investigate the use of tensile data to find the endurance limit of strain-ageable metals.

ABSTRACT: An equivalence exists between the proportional limit and the endurance limit of C-1118 steel. Rotating beam fatigue tests and cyclic tensile tests were performed on specimens of C-1118 steel at room temperature and 100°C. In the tensile tests, the specimens were cycled slightly above the proportional limit. The first few cycles produced strain hardening which resulted in an increase in the proportional limit. After the proportional limit reached a constant value, additional load cycles were applied from which an average proportional limit was calculated. This value was then compared with the endurance limit stress obtained from the fatigue tests. A very close agreement, less than 1 ksi difference or about 2.5%, was found between the proportional limit stress and the endurance limit stress at both room temperature and 100°C. The supposition is made that if a specimen is not stressed above the proportional limit, no energy is lost during loading and unloading, and under these conditions a specimen can endure an infinite number of cycles.

Based on previous testing on zirconium, it is believed that this phenomenon is true up to the recrystallization temperature. Above this temperature, the endurance limit for zirconium is higher than the proportional limit, and becomes even more so with increasing temperatures due to the increased mobility of dislocations and increased rate of recrystallization.

REVIEW: In this brief and clearly written paper, the authors have obtained a very close correlation between the proportional limit and the endurance limit stresses for C-1118 steel. Substantiating data and graphs are presented for complete clarification of the results. In a private communication the first author has stated that "the proportional limit about which we have written is obtained after several cycles of loading and unloading and is therefore numerically different from the ordinary proportional limit."

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65N15065

Serial Number 2150
ASQC Code 090

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability and failure of electronic equipment, systems, and mathematical models: a bibliography

AUTHOR: Carlotta M. Vidoni, Lawrence Radiation Laboratory, University of California, Livermore, California

SOURCE: UCRL-12040, 59 pp., University of California, Lawrence Radiation Laboratory, Livermore, California, Contract No. W-7405-eng-48, October, 1964 (NASA accession number N65-15065)

PURPOSE: To present a bibliography on reliability covering the period from January 1961 through April 1964.

ABSTRACT: This selective bibliography of about 400 entries is listed alphabetically by title, and covers the period January 1961 to April 1964. References were compiled from the following abstracts:

- Abstracts of Classified Reports, AEC
- Classified Scientific and Technical Aerospace Reports, NASA
- Electrical Engineering Abstracts
- Engineering Index
- Environmental Effects on Materials and Equipment, NAS, NRC
- International Aerospace Abstracts, AIAA
- Nuclear Science Abstracts, AEC
- Research and Development Abstracts, AEC
- Scientific and Technical Aerospace Reports, NASA
- Technical Abstract Bulletin, DDC
- Technical Translations, OTS

There is no author or subject index.

REVIEW: There are no abstracts or evaluations of the entries. The bibliography will be helpful even though it is not complete. The exact subjects included are not too clear; but large portions of the reliability field are covered. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Predicting test-program failures

AUTHOR: Richard H. Carlson, Senior Engineer, Raytheon Company, Lexington, Massachusetts

SOURCE: Machine Design, vol. 36, January 16, 1964, pp. 134-137

PURPOSE: To show how to schedule the test phase of a project.

ABSTRACT: A simple form of the Monte Carlo technique can predict the quantity, type, and duration of failures expected during a future test program. (Author)

REVIEW: It is difficult to understand the value of the statistical manipulations here or for what exact purpose these guesses are being made. Monte Carlo does not create a model of a situation; it is one of the techniques of analyzing a model (usually one too complex for analytic methods). When stripped of all the probability calculations, the essence of the paper seems to be that delays and problems on this project are likely to be the same as on similar projects when referred to unit time basis. The overall schedule can then be adjusted for the expected delays on a total time basis.

In general, much simpler "average experience" methods would be as good as or better than the use of probability techniques. ##

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Serial Number 2152
ASQC Codes 711;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Misaligned roller bearings...how fast will they fail?

AUTHORS: D. W. Dareing and E. I. Radzimovsky, Jersey Production Research Company, Tulsa, Oklahoma

SOURCE: Machine Design, vol. 36, February 13, 1964, pp. 175-179

PURPOSE: To derive equations to show the effect of misalignment on bearings.

ABSTRACT: The catalog life of roller bearings is based on negligible misalignment. If the bearings are non-aligning, then some of the rollers will be loaded more heavily than is normal for that load. This analysis makes the following assumptions:

1. The rollers are cylinders.
2. The bearing is at least moderately loaded (i.e. the upper rollers are not loaded at all).
3. The 3-dimensional stress problem is simplified by assuming the roller and races consist of a number of laminar springy discs.
4. Elastic limits are not exceeded. Failure is by fatigue as usual.
5. There may or may not be separation between part of the roller and the raceway.
6. The life of the bearing is that which it would have if the calculated maximum load were the maximum load of a properly aligned bearing.

Several curves are presented for ease in making the calculations.

REVIEW: This is a good theoretical paper; it attempts to state all the assumptions that are made in deriving the final equations. (Not all the mathematics was checked.) There is no experimental test of the theory, and without that, the theory must certainly be regarded as provisional. In the example, a misalignment of 0.5 milliradians causes a loading increase of over 50%. It should be noted in this respect that alignment to 0.1 milliradians (0.1 mil per inch) would be quite good. Obviously then, some misalignment is allowed for in the ratings which are themselves empirically determined. Other effects such as axial loads can also be important. (The term "expected life" is used; the life of a particular bearing is not predictable except statistically. The B-10 life--only 10% are expected to have a shorter life--is usually specified.) ##

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Serial Number 2153
ASQC Codes 711;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Determining preload in a bolted joint

AUTHORS: Thomas C. Baumgartner and Francis R. Kull, Standard Pressed Steel Company, Jenkintown, Pennsylvania

SOURCE: Machine Design, vol. 36, February 13, 1964, pp. 180-185

PURPOSE: To describe methods for preloading bolts.

ABSTRACT: A fastener which may fail in fatigue must be properly preloaded. In this way the alternating load on the bolt is usually reduced considerably although the maximum load is of course much higher. The net result, however, is to reduce the damage due to cyclic loading. There are three general ways of controlling the preload. These are:

1. Measure elongation of the bolt
   (a) directly
   (b) by turns of the nut
   (c) strain gage inside bolt--stress
   (d) (ultrasonic measurement of length)
2. Measure bolt preload
   (a) special load-indicating washer
   (b) auxiliary elongation of the bolt
3. Measure torque
   (a) hand torque wrenches
   (b) power tools; slipping clutches, impact tools, motor torque, etc.

Each of these methods has advantages and disadvantages in required access to the bolt, bolt cost, assembly cost, ease of checking, special tools required, and accuracy. There is not one best method. The design engineer has to decide on the required accuracy on the basis of the total cost of that accuracy.

REVIEW: This is a good article for designers who may need to be familiar with the ways of specifying bolt preload. There is adequate detail for this purpose and seven references are given for further information. ##

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Serial Number 2154
ASQC Code 813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: How to set up a reliability control program

AUTHOR: Normal Gellman, Avien Corporation, Woodside, New York

SOURCE: Machine Design, vol. 36, March 26, 1964, pp. 146-150

PURPOSE: To present a framework for a reliability program.

ABSTRACT: Reliability can be concerned with minimum guaranteed life, performance for a given time, failure rate or warranty. The reliability group should have electrical, mechanical, and statistical background but need not be large. In the program itself, engineers will estimate reliability from the basic design, pass on specifications for parts, conduct a design review, make reliability estimates at appropriate other times, check the qualification test, review the acceptance criteria, conduct failure analysis and reporting, and train all necessary people in the basic reliability concepts. All groups in the plant share in making a reliable product: marketing and contracts, engineering, quality control, purchasing, and field service.

REVIEW: This is a very brief paper that could provide management with the main ideas involved in carrying out a reliability program. It will at least provide familiarity with some of the words that are used in talking about reliability. (In some places, "exponential behavior" is implicitly assumed.) When warranty is discussed, presumably the expressed warranty is meant. ##

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Serial Number 2155
ASQC Codes 832;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Using human-factors engineering to prevent electrical-connector failures

AUTHORS: Joseph L. Seminara, Bioastronautics and Meyer Weinstein, Polaris Human Engineering, Lockheed Missiles and Space Company, Sunnyvale, California

SOURCE: Machine Design, vol. 36, August 27, 1964, pp. 158-165

PURPOSE: To describe problems with connectors in the field.

ABSTRACT: Reports on weapons-system performance in the field reveal electrical connectors as a recurrent source of difficulty--with consequences ranging from inconvenience to mission failure. A major cause of such malfunctions is the increased complexity, but vastly reduced size, of multicontact connectors. In any connector, no matter how miniaturized, every pin must stay in near-perfect alignment while maintaining stable, low-resistance electrical contact. The tiny pins must tolerate repeated mating with their sockets. One survey reports the following causes for 170 Minuteman connector failures.

Failure Mode	Reported Failures
Recessed Pins	98
Bent Pins	41
Damaged Inserts	14
Broken Pins	11
Unbonded Insert	4
Nonguide Keying	2

Even though connectors are keyed, miskeyed ones can be put together with just a little ingenuity. Tools, while not "allowed," are one method of doing damage. Sometimes it is very difficult, due to equipment design, to get at the connectors for proper assembly. Cables must be properly fabricated; three-dimensional boards are sometimes necessary. Contact identification is difficult. Checkout is important, but no one method is easy to use and foolproof. Electrical continuity checks are common; X-ray views can be used; a transparent connector design is being evaluated. Inspection and handling are also problems. Pins can easily be bent too far, but not be noticeable. Optical gages have been developed to assist here, as have more tolerant connectors. Protective covers have advantages if they are not mismated. Several references are given. (Authors in part)

REVIEW: This is a good discussion of what's wrong with connectors and the people who design, specify, and use them. Some suggestions are made for improvement all along the line. The paper has a different slant than those written by connector manufacturers. ##

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Serial Number 2156
ASQC Code 824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Estimating cyclical life for equipment experiencing only wearout failures

AUTHOR: J. E. Comer, Gulton Industries, Inc., Engineered Magnetics Division, 13041 Cerise Avenue, Hawthorne, California

but see 65A 26059

SOURCE: Electrical Design News, vol. 9, May, 1964, pp. 128-130

PURPOSE: To show how to calculate reliability when part life has a Gaussian distribution.

ABSTRACT: If a part has a known Gaussian distribution the reliability of the part for a particular mission can be calculated. Likewise, if the relationship of μ and σ are known, and the reliability is given, then μ and σ can be calculated.

REVIEW: This paper is worse than useless since it is misleading. The formulas are wrong and the terminology is partly wrong. The term random behavior is used where the special case of Poisson behavior is intended. In a private communication the author has indicated that he has rewritten his paper but did not say where it would be published. ##

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6

Serial Number 2157
ASQC Code 837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: "Worst case analysis" in analog circuit design

AUTHOR: P. A. Milone and Frank J. Sposato, Consolidated Avionics Corporation, Westbury, New York

SOURCE: Electronic Industries, vol. 23, March, 1964, pp. 78-81

PURPOSE: To present worst case analysis.

ABSTRACT: This article describes how a basically digital method can be applied to analog circuits. Three basic design areas are considered.

1. Circuit analysis (a mathematical analysis of each circuit).
2. Component derating (to insure optimum life-time values).
3. Quality assurance (aging, life and sample testing).

The expected maximum deviations of each parameter from its nominal value should be estimated and the circuit equations checked for each of these worst case conditions, together with the worst combinations of these deviations. Some common design techniques such as positive feedback for increasing gain are found to be poor from a reliability standpoint. Parts should be adequately derated and completed units should be burned-in. Occasionally some units should be tested to failure to determine the necessity to re-evaluate and check worst case analysis. (Authors in part)

REVIEW: There is a good message in this paper but it is a little hard to find. Perhaps for editorial reasons, too much is packed into too little space. (There is also some editorial confusion in the appendices.) The terms "worst case" and "end of life" tolerance have ambiguous implications and it is difficult to know what an author really means by them. But the principle of making engineering estimates of upper bounds on deviations likely to occur (but short of catastrophic failure) is a good one. If the equipment can reasonably be designed to operate at those bounds without undue complexity, the designer should by all means do so. When analyzing performance parameters, it is usually a good idea to check the effect of parameter swings on the total system performance rather than just element performance.

Whether one calls it "worst case" or not, the authors' proposals for checking performance equations are good ones and design engineers would do well to take them to heart. ##

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6

Serial Number 2158
ASQC Code 770

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Evaluation of radioactive gas accumulation leak test for semiconductor encapsulations

AUTHORS: J. E. Clark and M. S. Jones, Bell Telephone Laboratories, Inc., Allentown, Pennsylvania and R. F. Karoly, Western Electric Company, Inc., Allentown, Pennsylvania

SOURCE: 8 pp., presented at the Electrochemical Society Meeting, Washington, D. C., October, 1964

PURPOSE: To determine the limitations of the radioactive gas accumulation (RGA) test.

ABSTRACT: The RGA test consists of two parts: (1) activation of an encapsulated device in high pressure krypton 85 and nitrogen and (2) counting of the gamma radiation from gas that has entered and become trapped in the device encapsulation. These experiments consisted of leak testing Western Electric 12-M semiconductor devices and comparing the results obtained by RGA with mass spectrometer tests. (The 12-M transistor is a pnp germanium alloy device similar in configuration to the industry standard TO-5.) In addition, specially made testers containing leak rates in the range of $> 10^{-5}$ to $< 10^{-8}$ atm cm^3/sec were measured by RGA and compared with measurements made on the same units by the pressure rise method (for leaks 10^{-2} to 10^{-5}), by a helium mass spectrometer test (for leaks 10^{-3} to 10^{-8}), and by an argon gas accumulation test (for leaks 10^{-8} to 10^{-12}). Results show that: (1) the RGA spots leakers on a go/no-go basis under all conditions when the actual leak rate is in the 10^{-5} to 10^{-8} range; (2) at higher leak rates (above 10^{-5}) the radioactive gas may escape so rapidly as to permit leakers to slip by unless a getter such as unreconstructed glass is present; (3) at the smallest leak rates (below 10^{-8}) RGA measured higher values of leak rates than the actual (as determined by the argon accumulation test). (Authors in part)

REVIEW: The authors have succeeded well in briefly outlining the performance to be expected from the RGA leak test. Although it appears that further investigation could well extend the range and type of information that such a test could reliably provide, the boundaries that presently define the region of valid leak rate data are clear. The presentation does assume familiarity with previous work. Very few references are cited and the details of the techniques are largely omitted. The paper reports primarily the experimental results and the conclusions that can be reasonably inferred therefrom. ##

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64A19561

Serial Number 2159
ASQC Code 838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Majority voting protects aircraft and pilot

AUTHORS: H. Moreines, R. Worthington and F. Thomas, Flight Control Laboratory, Eclipse-Pioneer Division, Bendix Corporation, Teterboro, New Jersey

SOURCE: Electronics, vol. 37, May 18, 1964, pp. 85-91

PURPOSE: To describe a voting scheme for analog circuits and the redundant equipment which uses it.

ABSTRACT: The fail-operative requirement is an overriding consideration in designing critical subsystems for high-performance aircraft. Such a subsystem is stability augmentation where stability is increased by the automatic operation of control surfaces to compensate for minor disturbances, whether the pilot is in active command of the aircraft or not. Equipment must facilitate failure detection, display and fault isolation, while maintaining simplicity of circuit design to minimize power dissipation, weight, volume and cost. The system uses a voltage amplitude monitoring concept; the signals are analog and vary continuously. The voter is on-line, and continuously selects and transmits a signal having an intermediate amplitude among three input signals; that is, it ignores hardovers, null failures, degraded signals and the like. The monitoring function is off-line and provides the necessary logic to determine malfunctions, in a manner that in no way interferes with or interrupts the channel signal path. In fact, the monitor's malfunction threshold may be adjusted to any level of signal degradation as determined by system performance requirements. The three control axes (roll, pitch and yaw) of a typical system have to be completely separated or isolated to prevent failures in one axis from affecting any of the other control axes; this requires separate electrical power in each axis. Also, to keep a single failure from inactivating two channels at one time, within each axis (roll, pitch or yaw) the power supplies are triplicated to maintain independence of the three channels of the axis. A strong advantage of this system is the virtual elimination of transients that are allowed to pass or are caused by more conventional switching circuits. The analog voter is described. (Authors in part)

REVIEW: This is a good applications-design paper. The ideas appear to be sound and they are well described. There are no hardware results, so that there is no indication of what may happen when unexpected difficulties have had a chance to crop up. It should always be remembered that redundancy offers little protection from common hazards. ##

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8/65

64N82687

Serial Number 2160
ASQC Codes 090;715;782

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Radiation effects on electronic components: an annotated bibliography

AUTHOR: (compiled by William L. Hollister)

SOURCE: Special Bibliography SB-62-13, 94 pp., April, 1962, Lockheed Missiles & Space Company, A Group Division of Lockheed Aircraft Corporation, Sunnyvale, California; Work performed under U. S. Air Force Contract No. AF04(647)840 (DDC AD No. 277840)

PURPOSE: To provide a bibliography on the effects of nuclear radiation on electronic components.

ABSTRACT: This bibliography was compiled in connection with a study of the radiation effects on electronic equipment. Information was gathered on the effects of mixed reactor radiation on transient conditions and damage in the electronic equipment.

The sources consulted include the holdings of LMSC, Technical Information Center, report literature, recent journals, symposia, and conferences. The abstracts are arranged alphabetically by author. (Author in part)

REVIEW: There are 201 references in this bibliography, the bulk of which are dated in the late 1950's. A short abstract is given for each, and they are classified by subject in an index.

More recent papers on the effects of nuclear radiation which have been covered by RATR are found under ASQC Codes 715;782. ##

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8/65 63N17753 Serial Number 2161
ASQC Codes 090;782

R E L I A B I L I T Y A B S T R A C T S A N D T E C H N I C A L R E V I E W S

TITLE: High-vacuum effects on electronic parts, materials, and related problems: an annotated bibliography

AUTHOR: (Compiled by Eugene E. Graziano)

SOURCE: Special Bibliography SB-62-15, 62 pp., April, 1962, Lockheed Missiles & Space Company, A Group Division of Lockheed Aircraft Corporation, Sunnyvale, California; Work performed under U.S. Air Force Contract No. AF04(647)787 (DDC AD No. 282717)

PURPOSE: To provide a bibliography of technical information on experience with electronic parts and materials in high-vacuum environments.

ABSTRACT: This bibliography resulted from a literature search made to collect information on the effects of high-vacuum environments on electronic parts and materials. Due to the relative sparseness of such information, the scope of the search was extended to include selected references on sublimation, vapor pressures, electronic phenomena in high-vacuum, etc. An intensive search was made for the period January 1960 - March 1962, and selected references were included to earlier materials if citations were made to these earlier articles in the current literature.

The following sources were consulted:

- Applied Science and Technology Index, 1960 - February 1962
- Armed Services Technical Information Agency, Technical Abstract Bulletin, 1960 - February 1962
- Astronautical Information, Open Literature Survey, 1959 - February 1962
- Astronautics Information, Abstracts, 1959 - February 1962
- Engineering Index, 1960
- Environmental Effects on Materials and Equipment, 1961 - February 1962
- International Aerospace Abstract, 1960 - February 1962
- Lockheed Missiles and Space Company Library, Palo Alto, California
- Nuclear Science Abstracts, 1959 - February 1962
- Science Abstracts, Section A, 1960 - 1961
- Science Abstracts, Section B, 1960 - 1961
- Solid State Abstracts, 1961 - February 1962 (Author in part)

REVIEW: There are 124 references in this bibliography. An abstract is given for each, and they are classified by subject in an index.

More recent papers on the effects of high-vacuum environments which have been covered by RATR are found under ASQC Code 782. ##

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Serial Number 2162
ASQC Codes 716;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A method for predicting the strength degradation in an underground environment of polyester fiberglass laminates

AUTHORS: R. E. Heitman and R. S. Lindstrom, Arthur D. Little, Inc., Acorn Park, Cambridge, Massachusetts

SOURCE: Proceedings 19th Annual Technical and Management Conference, Reinforced Plastics Division, The Society of the Plastics Industry, Inc. (250 Park Avenue, New York, New York 10017), Chicago, Illinois, February, 1964, Section 4-F, 9 pp.

PURPOSE: To describe the technique used to interpret data obtained in a series of accelerated aging tests on sprayed-up polyester fiberglass laminate.

ABSTRACT: The sprayed-up polyester fiberglass laminate was tested for accelerated degradation due to being buried in the ground. The ground environment was simulated by buffer solutions of pH 3,7 and 10 representing the extremes likely to be found and a center point. Temperature was chosen as the accelerating parameter. In the two models, broken bonds were assumed to be the degradation mechanism. In the first model, the bond breaking was assumed to be rate limited and the solution concentration to be constant. The second model presumed that the degradation products would clog up the system somewhat and that the reaction would be diffusion limited. In both models the reaction was presumed to be first order. The second model seemed to fit the data better and was used for extrapolation to operating temperatures.

REVIEW: This is a straightforward paper describing two models which were compared with the data and the one that fits the best was accepted. In both cases, the assumption of a first-order reaction is made without justification or comparing that model with one for a non-first-order reaction.

Accelerated testing and models for extrapolation are very important and this applications paper can help shed some light on the problems encountered. ##

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8/65

Serial Number 2163
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure mechanisms for filament reinforced plastics subjected to static compression, creep and fatigue

AUTHOR: L. J. Broutman, Research Engineer, IIT Research Institute, 10 W. 35th Street, Chicago 16, Illinois

SOURCE: Proceedings 19th Annual Technical and Management Conference, Reinforced Plastics Division, The Society of the Plastics Industry, Inc. (250 Park Avenue, New York, New York 10017) Chicago, Illinois, February, 1964, Section 9-C, 10 pp. (See also Modern Plastics, vol. 42, April, 1965, pp. 143, 145, 148, 150, 153, 214, 216)

PURPOSE: To investigate crack initiation during simple compression tests, creep tests and fatigue tests.

ABSTRACT: Optical inspection of sample cross sections after testing is a valuable technique for studying crack initiation. The use of the electron microscope for studying the glass-resin interface has provided sufficient magnification to obtain details which could not be picked up by a light microscope.

Crack initiation at the resin-glass interface occurs in a simple compression test at stresses representing less than 80 percent of the ultimate stress. These cracks are separations at the resin-glass interface and are less than 0.05 microns wide.

Specimens which have been subjected to creep loads (80 percent of compressive strength) and fatigue loads (80 percent of compressive strength) have larger cracks both at the interface and throughout the matrix yet still support load.

It appears as if the 26 percent resin material suffers more delamination than the 19 percent resin material in the simple compression tests as evidenced by the greater number and size of cracks in this material when inspected after failure. In general, it appears as if fatigue loading is the most critical type of loading as more severe cracking was observed in fatigue specimens prior to ultimate failure than in the creep or simple compression specimens. This indicates that cracking can exist in the material before ultimate failure, and if this cracking goes undetected it can act as sites for environmental attack. (Author in part)

REVIEW: This is a physics-of-failure type of paper and does make a good contribution in this area. For many structural materials, such as filament reinforced plastics, there is so little known that design for very high reliability is virtually impossible. Studies such as these are a big help. ##

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Serial Number 2164
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The role of stress corrosion in glass fibers

AUTHORS: D. L. Hollinger and H. T. Plant, General Electric Company, Schenectady, New York

but see 66X12328, 65N19022, 65N14228, 64N28546

SOURCE: Proceedings 19th Annual Technical and Management Conference, Reinforced Plastics Division, The Society of the Plastics Industry, Inc. (250 Park Avenue, New York, New York 10017) Chicago, Illinois, February, 1964, Section 11-A, 13 pp.

PURPOSE: To investigate the influence of water vapor corrosion on the ultimate tensile stress of E-glass fibers.

ABSTRACT: It has been demonstrated that the instantaneous strength of E-glass fibers, produced in a normal atmosphere, can be nearly 1,000 ksi. This strength level is obtained by conducting tests at liquid nitrogen temperature, thereby greatly suppressing chemical reaction rates. The commonly measured strength of 500 ksi for E-glass fibers at room temperature is considered to be not limited solely by the crack structure existing before test, but by a stress-activated corrosion reaction during the test itself which increases the stress concentration at the tips of the cracks and leads to failure at lower applied loads.

An equivalent percentage increase in glass stress within composite ring structures is obtained by testing the rings at liquid nitrogen temperature, the comparable values being 500 ksi at -196°C and 310 ksi at room temperature. The apparent glass stress in rings, however, calculated simply from the applied load and the supporting cross-sectional area of glass, remains lower than the tensile strength of the fiber at the same temperature. This reflects inefficient load distribution, stress concentrations, and/or stress modes other than pure tension.

By performing tensile tests on single bare fibers of E-glass submerged in a powerful desiccant solution at room temperature, strength values were obtained as high as 653 ksi. This is considerably higher than any found in room temperature tests at normal humidity and lends support to the theory that strength losses at room temperature can be prevented by keeping moisture away from the glass surface.

The methods of preparing and testing the fibers are given. (Authors in part)

REVIEW: This is a physics-of-failure paper which provides some more insight into the mechanism of failure of these glass fibers. More of these studies are essential if the materials are to be used in high-reliability designs. ##

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Serial Number 2165
ASQC Codes 713;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The crazing phenomenon and its effects in filament-wound pressure vessels

AUTHORS: George Epstein, Project Scientist, ARA, Inc., 2017 West Garvey Avenue, West Covina, California and William Bandaruk, Supervisor, Plastics Section, Aeronutronic Division of Philco Corporation, Newport Beach, California

SOURCE: Proceedings 19th Annual Technical and Management Conference, Reinforced Plastics Division, The Society of the Plastics Industry, Inc. (250 Park Avenue, New York, New York 10017) Chicago, Illinois, February, 1964, Section 19-D, 7 pp.

PURPOSE: To describe the phenomenon of crazing, and to discuss its degrading effects on the structural properties of filament-wound reinforced-plastic composites.

ABSTRACT: Filament-wound cylindrical pressure vessels were tested by internal pressure. A crazing threshold was observed, viz., there is a strain below which laminar (subsurface) crazing does not occur. At this threshold the stress-strain curves have a knee. Elastic modulus of the composite was observed to be significantly reduced by this phenomenon. Analysis of the data suggests that crazing also reduces the potential ultimate strength (burst pressure). Permanent dimensional changes (set) in such structures also appear to be related to the development of laminar crazing. Improvements expected by eliminating the formation of crazing in filament-wound pressure vessels are:

1. Wet strength retention and water absorption.
2. Fatigue life.
3. Permeability/Leakage.
4. Permanent set.
5. Creep-rupture strength.
6. Stiffness.
7. Ultimate strength.

Based on experimental results and analysis of the data, a theory has been postulated to define the mechanism of crazing in filament-reinforced pressure vessels. (Authors in part)

REVIEW: This discussion is limited to internal pressuring so that the results are not necessarily applicable to compressive stresses found in deep submergence structures. Nevertheless, information on failure modes and mechanisms is needed so that such conditions can be either eliminated or allowed for with a high degree of certainty. ##

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Serial Number 2166
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A microscopic study of mode of fracture in filament wound glass-resin composites

AUTHOR: Charles A. Bouc, College of Technology, University of Maine, Orono, Maine

but see 63N10503.

SOURCE: Proceedings 19th Annual Technical and Management Conference, Reinforced Plastics Division, The Society of the Plastics Industry, Inc., (250 Park Avenue, New York, New York 10017) Chicago, Illinois, February, 1964, Section 19-G, 10 pp.

PURPOSE: To investigate the modes of fracture in filament reinforced plastics under tensile stresses.

ABSTRACT: Filament wound glass-resin specimens were successfully developed to simulate a typical filament wound composite such as found in pressure vessels and fuel tanks. During tensile loading each specimen was carefully scanned at a magnification of x200, and a written and photographic record was made of the progress of the fracture. The information thus obtained was synthesized into identification of five different microscopic and macroscopic modes of fracture. Their origin and nature were investigated and their contribution to the progressive and ultimate fracture of the specimens determined. The following conclusions seem justified:

1. These specimens offer a realistic approach to the study of glass resin interaction. Most of the various types of fracture observed are known to occur in prototype structures.
2. The weight ratio of resin to glass affects the ultimate strength. A high resin content reinforces filaments at weakened areas not by aiding in carrying of the tensile load, but by shifting load from these weakened areas to stronger adjacent filaments by means of shear transfer.
3. The weight ratio of resin to glass determined the types of micro- and macroscopic fracture that occurred. An explanation is not apparent at this time though a study of energy dissipation in resin at a resin crack root may clarify this problem.
4. The occurrence and spread of debonding failures was the mechanism that had the major influence on ultimate fracture.
5. The relative prominence of the various types of modes of fracture will be affected by changes in variables, but their qualitative nature is not expected to be altered. (Author in part)

REVIEW: This sort of failure mode and mechanism data is needed so that engineers may more intelligently design filament reinforced plastic structures. At present there is not enough information available for designs of very high reliability. ##

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Serial Number 2167
ASQC Codes 820;864

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability estimation from field failure data

AUTHOR: Howard R. Roberts, Research Director, Statistics, Booz-Allen Applied Research Inc., Bethesda, Maryland

SOURCE: Journal of the Electronics Division, American Society for Quality Control, vol. 2, March, 1964, pp. 3-15

PURPOSE: To derive some expressions for use in analyzing data when some non-failed items have been withdrawn from test.

ABSTRACT: In some life tests random numbers of test items are withdrawn from the test at random times. A non-parametric estimate of reliability in this situation is derived. Then the "accidental death" model is introduced and maximum likelihood estimates of the parameters of simple models are obtained. Several examples are given.

REVIEW: This is a good paper although it is limited to the statistical analysis of field data rather than to assessing their engineering validity. The result in the case of parameter estimation for exponential behavior (in the event of withdrawals) is interesting in that the mean failure time estimate is just (total test time)/(number of failures).

The results should be of value to engineers although it would be wise for them to have statistical assistance in their use.
##

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Serial Number 2168
ASQC Codes 512;555;821

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Minimum sample size for accepting a criterion error or failure rate with a given degree of confidence

AUTHOR: Irving Belson, Staff Statistician, Product Testing Laboratory, IBM General Products Division, Endicott, New York

SOURCE: Journal of the Electronics Division, American Society for Quality Control, vol. 2, March, 1964, pp. 16-23

PURPOSE: To describe a technique which quickly gives the minimum number of operations that are needed to accept a criterion error or failure rate with a specified degree of confidence.

ABSTRACT: It is often necessary to test a machine for a specified error or failure rate (referred to in this paper as a criterion rate), and to arrive at a decision with a specified degree of confidence. An important factor in organizing such a test is its length. This paper describes a technique which quickly gives the minimum number of operations that are needed to accept a criterion rate with a specified degree of confidence. It can be utilized to determine the confidence limit for zero failure rates in the exponential or binomial case. This approach is based on no errors being found during the test, and on the assumption that we are dealing with a binomial population in which each sample or operation is either a success or failure, and the probability of success or failure is constant. The errors may be random or chance, but not a function of wear. Equation (1) provides the minimum sample size N to accept a criterion rate with confidence γ, if no errors are found.

$$N = \frac{A}{R} \tag{1}$$

where $A = -\ln(1 - \gamma)$, γ = confidence
R = criterion rate, ≤ 0.01
N = sample size or number of operations.

An example is given, and a nomograph based on Equation (1) is provided. If errors are observed, a method of analysis other than that based on Equation (1) must be used. A method based on the negative exponential is outlined, and a nomograph for it is also provided. (Author in part)

REVIEW: This is a straightforward paper which presents quick methods of determining minimal sample size for accepting a criterion rate in the cases to which they are applicable. Their main role will be in providing a rough idea of test magnitude when no prior information or past performance history data are available. The mathematical aspects of the paper are clearly presented, and adequate references are cited for those who desire more detail on the background material. ##

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Serial Number 2169
ASQC Code 823

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Hypercensored life testing

AUTHOR: Howard R. Roberts, Booz-Allen Applied Research, Inc.

SOURCE: Journal of the Electronics Division, American Society for Quality Control, vol. 2, March, 1964, pp. 24-32

PURPOSE: To find an estimate of mean time-to-failure in the exponential case under hypercensorship.

ABSTRACT: The term hypercensorship (Type I) is used to describe sampling situations which involve the withdrawal from test of a fixed number of items at each time of failure. The analysis is based on an exponential distribution of times-to-failure. The maximum likelihood estimate of the parameter is derived. Confidence limits are established, and criteria for hypothesis testing are obtained. An example is given.

REVIEW: While the results in this paper appear quite correct, their similarity to estimates for other censorship methods is not pointed out. The estimate of mean time to failure can also be expressed as (total test time)/(number of failed units). This is also true in a different situation treated by the author in an earlier paper (see RATR 2167). It would be interesting to prove that the maximum likelihood estimate is always the same for the exponential situation regardless of the type of censorship. No comments were made on any other statistical properties of this specific estimator. ##

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Serial Number 2170
ASQC Codes 810

720;813

838

831;836;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

Ga

TITLE: Current management reliability objectives

AUTHOR: Lysle A. Wood, The Boeing Company, Seattle, Washington

SOURCE: Journal of the Electronics Division, American Society for Quality Control, vol. 2, December, 1963, pp. 6-10

This paper is identical to the one covered by RATR 1106.

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would see 66A28802

TITLE: A program of quality assurance for welded electronic circuitry

AUTHOR: F. A. Lally, The Boeing Company, Aero-Space Division

Ga

SOURCE: Journal of the Electronics Division, American Society for Quality Control, vol. 2, December, 1963, pp. 15-22

This paper is virtually identical to the one covered by RATR 1178.

Ga

TITLE: A duplex redundancy scheme to obtain high reliability computers

AUTHOR: R. W. Lowrie, Minneapolis-Honeywell Regulator Company, St. Petersburg, Florida

SOURCE: Honeywell Aero Document U-ED29109, 12 pp., 4 January 1963

The essentials of this paper are in the one covered by RATR 1167.

TITLE: Computer speeds circuit design reviews

Ga

AUTHOR: Robert H. Cushman

SOURCE: Electronic Design, vol. 13, February 15, 1965, pp. 12-15

This is a summary of the paper covered by RATR 1818. ##

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Serial Number 2171 -1
ASQC Codes 522;837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

65N23779

TITLE: Switching circuit transient performance prediction using empirical modeling techniques

AUTHORS: J. B. Tommerdahl and A. C. Nelson (Research Triangle Institute, Durham, N. C.)

SOURCE: IEEE Transactions on Reliability, vol. R-14, Mar 65 (published May 65), p. 5-14

...

65N86880

TITLE: Study of failure rate distributions of series-parallel configurations

AUTHORS: J. B. Tommerdahl and A. C. Nelson (Research Triangle Institute, Durham, N.C.)

SOURCE: Final Report, Signal Corps Contract No. DA-36-039-SC-90822, DA Project No. 3X90-90-004, 1 Jul 62 to 30 Jun 63 (AD-418 608)

...

PURPOSE: To present a procedure for obtaining quasi-empirical mathematical models which relate the performance parameter of interest to the pertinent variables.

ABSTRACT: The IEEE Transactions paper (first SOURCE) is a condensation of the report (second SOURCE). Once the nominal values of circuit parts are known, the nominal performance of the circuit can be measured. A designer needs to know more than this, however; he needs to know what happens to performance when the part values deviate from nominal. In many cases, especially for nonlinear circuits, it is easier to make an empirical evaluation of the effect of these deviations. For a given form of an assumed equation, which relates the performance to the pertinent parameters, methods of statistical design can be used to determine the number of circuits to be constructed. The necessary circuits are built and the performance data are taken. When this is done the unknown parameters of the equation are evaluated from the data along with the various uncertainties in the estimates. These equations are then useful for interpolation (but not extrapolation).

The technique is demonstrated for a medium-speed switching circuit in the paper (first SOURCE) and a linear amplifier in the report (second SOURCE). The circuits are described and the modeling procedure is outlined for determining pertinent performance parameters such as rise and delay times in the switching circuit and gain in the linear amplifier. Measured and predicted results are shown to be in good agreement.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

REVIEW: These papers fulfill their purpose reasonably well. As mentioned in RATR 2019, there is some question as to the meaning of "model". Apparently by "obtaining a model" the authors mean evaluating some unknown parameters in an equation, after the form of the equation has been explicitly assumed. The adequacy of the form can then be checked from the tests.

References are given to the literature and it is stated that "...the most notable difference between the work presented here and the cited references is the use of the statistically designed experiment in place of the random selection of components." Once one has the performance equations, the suggested things to be done with them are fairly standard (that is, it is standard to suggest them; how many designers follow the standard suggestions is something else again). The cautions against extrapolation are well taken. The suggestion that "for many problems, the means and variances are all that one needs for optimizing the performance of the circuit" is not quite accurate since if the distribution is very skewed instead of near-Normal the tails are not adequately described.

The approach described is best applied to long production runs of essentially identical systems, particularly if the number of variable parameters is appreciable. It can be especially useful in identifying sensitive parameters and determining permissible tolerances for component parameters. It permits greater freedom in specifying most components than would be the case using, for example, worst-case design.

In addition to the requirement that a number of carefully constructed models be built and tested, certain other limitations appear. Considerable engineering judgment must be exercised to limit the complexity of the model and to identify probable nonlinear effects so that additional models can be tested to properly evaluate the corresponding terms.

The papers do well in a careful adherence to correct mathematics and statistics (something not always found in the literature); for example, correlations between the variables are always taken into account in the calculations. ##

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65A23780

Serial Number 2172
ASQC Codes 831;872;882

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability prediction for continuously operating systems

AUTHORS: M. Plotkin and S. Einhorn (AUERBACH Corporation, Philadelphia, Pa.)

SOURCE: IEEE Transactions on Reliability, vol. R-14, Mar 65 (published May 65), p. 15-22

PURPOSE: To develop a method with few restrictions for the prediction of the reliability of a complex system designed for continuous operation.

ABSTRACT: The state of the system is defined by identifying the subsystems which are functioning; the remainder of the subsystems are all undergoing repair. It is assumed that maintenance facilities are always adequate. The system is considered as up whenever it is in one of an arbitrarily selected set of system states. Each subsystem can be in either of two states, up or down. The method considers series and parallel arrangements of non-identical subsystems. Forms of the distributions for up-times and down-times are not restricted to exponential conditions. Main formulas which are developed give the probability that the system is up, and the mean durations of system up-times and down-times; each formula is in terms of the mean durations of subsystem up-times and down-times. Sensitivities of the formulas to errors in the input data are considered. An example is presented for a simple system. (Authors in part)

REVIEW: This approach leads to the development of formulas suitable for realistic applications to continuously operating systems. The principal limitation which is avoided relative to current analysis techniques which consider redundancy is that of exponential distributions of up-times and down-times. Assumptions for this method are explicitly stated and discussed from the viewpoint of their limitations. Also, the treatment of sensitivity of the formulas to errors in the inputs is a desirable supplement. It should be noted that limitations overcome by this analysis approach can also be overcome by using Monte Carlo simulation. Basic derivations leading to the formulas are not presented, nor are they contained in the final report of the referenced supporting contract. It is not mentioned that the formulas are for steady-state conditions, which for non-exponential distributions of subsystem up-times and down-times would follow an initial transient period. RATR 2173 covers the derivation and presentation of the same general approach. ##

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65A23781

Serial Number 2173
ASQC Codes 831;872;882

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Steady-state reliability of systems of mutually independent subsystems

AUTHOR: Sidney P. Applebaum (Syracuse University Research Corporation, Syracuse, N. Y.)

SOURCE: IEEE Transactions on Reliability, vol. R-14, Mar 65 (published May 65), p. 23-29

PURPOSE: To present a method for the prediction of a system's steady-state availability and mean time between failure without requiring knowledge of the complete distributions of operate and repair times for each subsystem.

ABSTRACT: The method developed for predicting system reliability is simplified by subdividing the system into mutually independent subsystems. Results are obtained without knowing the failure or repair time distributions of the subsystems. Formulas are developed for the steady-state availability, mean time between failure, and mean down time of a complex system in terms of the same parameters of the constituent subsystems. The formulas are generally applicable to series-parallel arrangements of subsystems. Basic concepts which are required are introduced and discussed for a simplex system; here the system is an entity without consideration of its subsystems. These basic concepts are then applied to a complex system whose subsystems are explicitly treated to obtain the main results. Two examples are given to illustrate the application of these results. (Author in part)

REVIEW: This approach leads to the development of formulas suitable for realistic applications to continuously operating systems. The principal limitation which is avoided relative to current analysis techniques which consider redundancy is that of exponential distributions of failure and repair times. The paper is well presented; it states and discusses the assumptions and concepts, and defines terms. A notation error is made in first using the subscript i for different time period durations and then later again using i for different subsystems. Relevancy of this approach to stand-by redundancy is not explicitly cited; however, it would seem that this form of redundancy would be handled by this general approach, perhaps requiring some modification. Those persons interested in practical reliability analysis techniques should read this paper. RATR 2172 covers a presentation of the same general approach. ##

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Serial Number 2174
ASQC Codes 431;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A probability method for determining the reliability of electric power systems

AUTHORS: C. F. DeSieno (American Electric Power Service Corporation, New York, N. Y.) and L. L. Stine (Stanford University, Stanford,Calif.)

SOURCE: IEEE Transactions on Reliability, vol. R-14, Mar 65 (published May 65), p. 30-35 (reprinted from IEEE Transactions on Power Apparatus and Systems, Feb 64)

PURPOSE: To develop a method for determining the reliability of transmission and distribution networks for electric power systems.

ABSTRACT: A power system state is defined by each combination of the failed and operating components which carry electricity from sources to loads. The states which cause power flow to a specified load to be interrupted are system failures. The success combinations can be described by a Boolean algebra expression; for complex electric power systems, computer methods might be developed which would reduce complex systems to logic networks for which a Boolean algebra expression for success could be written directly. When the rates of component failures and repairs are constant, the states behave like a Markov process. The reliabilities of some simple configurations may be analytically evaluated by solving the Markov equations by the method of Laplace transforms. Large complex systems may be solved more easily by simulating the process with a digital computer. The simulation process consists of generating component histories by the Monte Carlo method of sampling, comparing the resulting states with the Boolean expression for success, and counting the relative frequencies of various operation and failure durations. The analytical evaluations are illustrated for the reliability of three elementary component configurations found in power systems. (Authors in part)

REVIEW: The reliability analysis techniques presented here for electric power networks are the same techniques which have been extensively applied to military and space electronic systems. Typical assumptions of independence and simple Markov process are made. The material is well written and nicely presented. No operating data are presented for failure and repair distributions for electric power networks to justify the proposed modeling, nor is any experience presented for actual applications of these analysis techniques to realistic electric power systems. ##

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Serial Number 2175
ASQC Code 814

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Economics dictates reliability

AUTHOR: L. N. St. James (Bell Telephone Laboratories, Whippany, N. J.)

SOURCE: IEEE Transactions on Reliability, vol. R-14, Mar 65 (published May 65), p. 36-39 (reprinted from IEEE Transactions on Aerospace, Apr 64) A 64A18112

PURPOSE: To support the viewpoint that a "lowest total cost system which will do what is expected of it" is likely to be obtained only if it is procured on a total annual cost basis.

ABSTRACT: The concept of an adequate system is introduced as the lowest cost system that will do what is expected of it whenever called upon. Attributes of an adequate system are presented which result from minimizing total cost. Reliability is included in the availability requirement and is not explicitly mentioned. Relevant experiences from the Zeus Data Processing system are discussed. Some major conclusions from this program are that (1) lower part failure rates and system repair times are needed, and (2) lowest annual user cost demands that the system use the lowest failure rate parts attainable. The conclusion is reached that procurement of systems on the basis of total annual cost to the user is possible and should bring about substantial savings. In order to do this, the user must give all resulting requirements to potential contractors so that they may make intelligent bids. Some of the tasks which a system supplier would have to do under such a contractual situation are presented.

REVIEW: Conclusions from earlier papers and experience from a system program are brought together to support a design approach based on total annual cost. Thus the topic of this paper is timely with the current emphasis on cost-effectiveness. An interesting conclusion which is supported from several directions is that for a system with an availability requirement of 99 percent, the lowest total cost system is obtained by minimizing failures and repair time, instead of utilizing significant redundancy. As with most current discussions on reliability and economics, the perspective is from the user's viewpoint and recommends approaches that users and suppliers should take in order to best satisfy the user's operational and economic objectives. Little is presented to indicate the impact of these recommended approaches on the supplier's economic and associated objectives.

An earlier paper on this topic by the same author was covered by RATR 1297. ##

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Serial Number 2176
ASQC Codes 837;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A new design tool: the matched characteristic method of nonlinear analysis

AUTHOR: Donald G. Mark (Battelle Memorial Institute, Columbus, O.; now with Motorola Inc., Military Electronics Div., Scottsdale, Ariz.)

SOURCE: IEEE Transactions on Reliability, vol. R-14, Mar 65 (published May 65), p. 40-51 (reprinted from IEEE Transactions on Aerospace, Apr 64) 64A18113

PURPOSE: To present an analytical method of describing transistor and diode characteristics and to show how their nonlinear behavior is used in circuit calculations.

ABSTRACT: The conventional descriptions of semiconductors are not adequate for circuit design. It has been found that, for a given type of transistor or diode, the various V-I curves of any individual can be transformed into those of any other (and thus to a standard) by appropriate linear transformations of the V's and I's. The exact nonlinear characteristics of a standard can then be specified graphically or by a table with sufficient points on it (and the use of linear interpolation between points). If the linear transformation coefficients are known for an individual, the table can be transformed to the characteristics of that individual. This can all be put on a digital computer and iterative methods can be used to find the operating points of the transistors and diodes for any circuits. Examples are given.

REVIEW: There appear to be two problems treated here. One is the assertion about being able to transform the characteristics of any transistor of a given type into those of any other transistor of the same type by certain linear transformations of the voltage and current. The second is that the nonlinear characteristics of a transistor should and can be used to determine the operating point. The utility of this method for a designer will depend to a large degree on how easy it is for him to put his problem on the computer and on the availability of the necessary data. To get an idea of the spread in performance will require some statistical description of the distributions of the linear transformation coefficients.

(There is nothing essentially wrong with the more empirical methods of circuit design even though the author implies that they are inferior. The important thing is that the circuit be properly checked out before it is released. An analysis of performance sensitivity to parts variation is essential, but this can also be empirically determined; see, for example, RATR 2171.) One important problem not treated here is just what portion of these characteristics is to be guaranteed by the manufacturer--an essential point for high reliability. ##

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Serial Number 2177
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Adequate failure analysis when life testing electronic equipment

AUTHOR: Everett S. Tomlinson (Motorola, Inc., Military Electronics Div.)

SOURCE: IEEE Transactions on Reliability, vol. R-14, Mar 65 (published May 65), p. 52-55 (reprinted from IEEE Transactions on Aerospace, Apr 64) C 64A18114

PURPOSE: To emphasize the importance of good failure analysis in any test program.

ABSTRACT: Careful and diligent failure analysis is necessary to obtain maximum benefit from life tests of electronic equipments. The importance of good failure analysis is often underrated in a test program, to the detriment of the program. This paper discusses the role and the significance of correct attitudes, advance indoctrination, thorough planning, skills, facilities, and effective supervision in adequately diagnosing each failure incident, in recording its details, and in preserving the lesson learned. Experience in such testing has led directly to the feeling that the importance of diligent, painstaking, documented failure diagnosis has been sold short in the industry.

If anyone claims not to have had failures on his particular black box, it follows that he has little information on his equipment's true capability. In life-testing, the occurrence of a failure is a pearl of great value. Every failure has a cause, if we can only discover it, and is an opportunity to learn and improve. The path to adequate failure analysis must begin with the development of proper attitudes in the minds of all concerned - including the technician, the designer, the component part specialist and the supervisor. (Author in part)

REVIEW: This is largely an exhortation (needed by many) to take life testing seriously and to learn from the analyses of failure. In essence the author suggests a negative attitude for testers, viz., "let's find out what's wrong or could be wrong with this," rather than an attitude of "let's hope it works." The points are well taken and necessary for a high reliability program. Probably the main problem arises when someone decides that the program he is on really is not important enough to justify the time, effort and expense. ##

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65A23782

Serial Number 2178
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure analysis of electronic parts

AUTHOR: David C. Porter (The Boeing Company, Aero-Space Division, P. O. Box 3707, Seattle, Wash. 98124)

SOURCE: IEEE Transactions on Reliability, vol. R-14, Mar 65 (published May 65), p. 56-65 (reprinted from IEEE Transactions on Aerospace, Apr 64)

PURPOSE: To recount experiences in failure analysis.

ABSTRACT: Failure analysis techniques can identify the probable causes of failure on a very significant percentage of failed parts. This effort has disclosed that failed parts are the products of abuse by the user and of defects of manufacture. It seems possible, and even likely, that these two areas of difficulty are so significant that at least one and maybe more orders of magnitude of reliability improvement could be achieved by concentrating on these causes. The exercise of sound engineering practices could eliminate these failure causes if there is recognition of their significance.

As a discipline, failure analysis should logically stand somewhere between life testing and the more basic physics of failure investigations. Life test results without the cross-check of failure mechanism identification may be very much in question because of the high probability of abuse failures. And, some parts available today appear to have no valid failure mechanisms and hence no basic physics of failure.

Many examples are given. (Author in part)

REVIEW: The paper deals for the most part with large changes in characteristics rather than with small ones which would cause some circuits to fail, but not others. The author finds most of them to be in the "foolish failure" category--the part obviously had a defect caused by poor design, production, or use techniques.

One sometimes wonders at the need for high powered reliability theory when so many failures are caused by this foolish lack of care.

(A condensation of this paper was covered by RATR 1639.) ##

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65N11191

Serial Number 2179
ASQC Codes 553;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Binomial reliability table (lower confidence limits for the binomial distribution)

AUTHORS: James R. Cooke, Mark T. Lee, and John P. Vanderbeck (U. S. Naval Ordnance Test Station, Test Dept., China Lake, Calif.)

SOURCE: NAVWEPS Report 8090, NOTS TP3140, U. S. Naval Ordnance Test Station, China Lake, Calif., Jan 64, 334p (AD-444 344; NASA accession number N65-11191)

PURPOSE: To provide tables for use in reliability estimation when the data can be classified into success or failure.

ABSTRACT: The following assumptions are inherent in the use of the binomial probability distribution:

1. The population is very large (infinite) in size. Thus, if the population is infinite, the probability of a favorable event, p, remains constant from sample to sample. For finite populations, the formula for the probability of k favorable items in a sample of n is only approximately correct; the accuracy of the approximation improves with increasing population size.
2. The sample is randomly selected from the population. That is, every item in the population must have the same probability of being chosen for the sample.

There are an introduction to the use of the tables and some examples. The tables list the lower one-sided confidence limit on the true population reliability p (proportion of reliable items in the population) for six confidence levels--80, 90, 95, 97.5, 99, and 99.5%; p is given to five decimal places; the range of n(sample size) is 4 through 500 by ones; the range of r (number of reliable items found in a sample of size n) is n/2 through n by ones when n is even, and (n-1)/2 through n by ones when n is odd. (Authors in part)

REVIEW: This will be a useful set of tables for those who need to make this type of calculation. As stated by the authors, the accuracy is more than sufficient for any engineering purpose. ##

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Serial Number 2180
ASQC Code 833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Field-relief electrode boosts transistor reliability

AUTHOR: --

SOURCE: Electronic Equipment Engineering, vol. 12, Sep 64, p. 18-20,22

PURPOSE: To describe the structure and explain the operation of the field-relief electrode.

ABSTRACT: In the past, inversion layers in the collector region of p-n-p planar transistors have been limited in area by surrounding the base-collector junction with a p^+ region. When the base contact is brought out over the oxide, however, the high electric field associated with the reverse biased collector-base junction is also extended out across the oxide beneath the base contact lead. The presence of this field aggravates the formation of inversion layers. By inserting a metal shield, connected only to the collector, between the extended base contact and the oxide-silicon interfaces (but isolated from each), the electric field across the oxide in the vicinity of the collector-base junction is reduced to near zero. The metal shield is called the field-relief electrode (FRE). FRE diodes and transistors show improved stability and exhibit no inversion.

REVIEW: This note describes a recent fabricational method important in p-n-p technology. Although brief, it is clear and complete in concept. The FRE should reduce the instabilities characteristic of high-temperature high-bias operation of planar devices, but it does not eliminate the n-type inversions observed to follow thermal oxidation.

The incorporation of an FRE into a device does involve more processing and can be expected to reduce yields--probably not alarmingly, however.

The scales, axis labels, and identification of the origin are omitted from Fig. 4 which may lessen its meaning for some readers.
##

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64A15107

Serial Number 2181 -1
ASQC Codes 844;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Mission reliability as a function of automatic checkout

AUTHOR: Robert A. Kirkman (Space Technology Laboratories, Inc., Redondo Beach, Calif.)

SOURCE: IEEE Transactions on Aerospace, vol. AS-2, Feb 64, p. 22-29

PURPOSE: To discuss how and why mission reliability is affected by checkout and the considerations involved in exploiting this fact to maximize mission reliability.

ABSTRACT: The mission reliability of a system is affected by operational test and checkout, independently of the apparent working of the system. This is accomplished in part by a screening process which detects abnormalities to be corrected, whether or not they have resulted in system failures. The viewpoint is adopted that the theoretical limit to equipment failures is zero, that a complete trade-off analysis is required to establish the optimal depth of test (together with related factors), and that much more comprehensive tests are justified. These are for fault detection; fault isolation is a by-product. The approach can be rationalized and reconciled with traditional statistical reliability. The important elements of the test rationale are, principally, system design-for-testability to permit a thorough test, implemented by an efficient and applicable automatic checkout equipment. The latter is a high-speed, internally-programmed machine. More attention to the influences of field testing on mission reliability to supplement other reliability approaches will have a pronounced effect upon the probability-of-success of our large systems. (Author in part)

REVIEW: There are some good fundamental ideas in this paper. Some of them question some well-entrenched interpretations of fundamentals of reliability engineering, but that is needed. Many of these interpretations have ignored the basic concepts of engineering, physics, and statistics. For example, it is often asserted that reliability cannot be inspected into a product; while this is partially true, it is also true (as the author says) that unreliability can be inspected out of a product. It is difficult for one person to see the details of all phases of a project at once and perhaps that is why some designers have failed to appreciate the full potential of complete checkout. To assert however that checkout can only improve the system is to forget that any kind of servicing may actually cause degradation. (In a private communication the author has stated that checkout can only hope to account for failures in the equipment itself, not those originating external to it.)

The paper discusses at some length the limitations of the component

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

failure rate approach. Perhaps a large source of trouble is that the conventional definition of reliability is incomplete. Implicit in the definition (and the formula $R = \exp(-\int_0^t h\,dx)$ is the assumption that the system works at $t = 0$ (viz., $R(0) = 1$). Now the statement that the system "works" or "is satisfactory" needs a lot of explaining. For example, a redundant system with one element out may be said to be working but that is not what we sometimes mean. If we have as the condition: given that everything in the system is as it should be, then of course the need for checkout is obvious--a system can be performing satisfactorily without everything being up to snuff. It would be well for some group to reconsider the definition of reliability to account for this explicitly.

The comments on randomness are good (see also RATR 1366). ##

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Serial Number 2182
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Fine structure and electromagnetic radiation in second breakdown

AUTHORS: W. M. Portnoy (Texas Instruments, Inc., Dallas, Tex.) and F. R. Gamble (Stanford University, Stanford, Calif.)

SOURCE: IEEE Transactions on Electron Devices, vol. ED-11, p. 470-478, Oct 64

PURPOSE: To report on an experiment to determine the nature of second breakdown by studying emitted radiation.

ABSTRACT: In studying the open-base behavior of several types of silicon devices, it was observed that second breakdown was followed by additional discontinuities at higher current levels, all similar to second breakdown in their electrical behavior. Simultaneously with the appearance of a voltage discontinuity, light was emitted by the device. The light output level generally increased monotonically with increasing collector current except when a voltage discontinuity occurred, at which time a discontinuous increase in the light output level also occurred. The spectral distribution of the emitted light was examined and found to be similar to the distribution from a single junction biased into avalanche. The results of the electrical measurements strongly suggest the existence of a number of interacting sites capable of sustaining second breakdown. The optical measurements indicate that the characteristics of a transistor in second breakdown are not purely thermal in nature, but that a plasma effect may be associated with a device exhibiting an anomalous breakdown. (Authors)

REVIEW: This paper is a very worthwhile contribution to the growing library of published work on second breakdown (SB). The intent of the experiments is to understand the mechanism of SB rather than to catalogue its symptoms or properties. Although it may be premature to conclude that all SB displays the structure reported here, the non-thermal radiation patterns that the authors found will have to be considered in the formulation of any complete model of SB. It seems likely that both junctions and structural imperfections in silicon give rise to regions of high electric field which contribute plasma-like structure to the electromagnetic spectrum in SB. SB characteristics have been reported in samples containing no p-n junctions (see RATR 2116). It would be interesting to see if fine structure can also be observed with such samples or whether the spectrum appears more like the junctionless bar of silicon already examined by the present authors.

Figures 8 and 9 showing the radiation spectrum of various samples in different operating modes and levels are particularly interesting. ##

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Serial Number 2183 -1
ASQC Codes 782;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

65A10205

I. TITLE: Trading off radiation resistance and second-breakdown performance

SOURCE: Electronics, vol. 37, 19 Oct 64, p. 48-51

...

65 N12650

II. TITLE: Secondary breakdown, radiation resistance and frequency response of silicon transistors

SOURCE: USAEL Technical Report 2463, U. S. Army Electronics Laboratories, U. S. Army Electronics Command, Fort Monmouth, N. J., DA Task NR.1G622001A056-01, Jun 64, 6p (AD-607 561)

...

III. TITLE: The effects of neutron radiation on second breakdown

SOURCE: Proceedings of the IEEE, vol. 52, p. 735, Jun 64 (correspondence)

...

IV. TITLE: The relationship between transistor secondary breakdown performance and VHF large signal amplifier performance

65N10490

SOURCE: Technical Report 2492, U. S. Army Electronics Laboratories, U. S. Army Electronics Command, Fort Monmouth, N. J., DA Task 1P622001A056-01, Jun 64, 5p

...

AUTHORS: Bernard Reich and Edward B. Hakim (Army Electronics Laboratory, Fort Monmouth, N. J.)

...

PURPOSE: To show the compromise required in achieving both high radiation resistance and good second breakdown resistance (I, II, III); to compare d.c. and VHF second breakdown performance (IV).

ABSTRACT: Design features of a transistor that reduce susceptibility to radiation damage, such as a high gain-bandwidth product, tend also to reduce resistance to second breakdown (SB). This conclusion is summarized in a plot of (1) second breakdown figure of merit and (2) radiation resistance vs gain-bandwidth product. The tolerable value of integrated neutron flux increases with increasing gain-bandwidth product, while the SB figure of merit decreases. The intersection of the two curves represents a practical compromise point for transistor design. Annealing cycles also influence the current thresholds of SB. The conclusions of IV are: (1) if secondary breakdown limits the performance of r.f. power transistors, the maximum power output of the device is limited by the d.c. operating point at which secondary breakdown occurs, and (2) visual inspection of units destroyed in these experiments has shown that consistent metalization failures have

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occurred in the vicinity of the emitter lead. The failures noted under r.f. conditions have been much more severe than those noted under d.c. burnout conditions. (Authors in part)

REVIEW: Little attempt is made to explain the physics of the correlation between radiation resistance and second breakdown resistance. However, the correlation is worth pointing out without further explanation and the authors do so effectively.

These presentations are marred by inadequate proof reading: (1) In I, the captions of two figures seem to have been interchanged; (2) the conclusion that second breakdown performance varies inversely with total thermal resistance is called "clearly evident" from the tabulated data on three single-diffused transistors and two alloy diffused types, but the figure of merit (FM) decreases with decreasing thermal resistance (Θ_{j-a}) in one case and increases in the other. Identical pairs of photomicrographs appear in I and IV but with somewhat different implications. In I the pair appears to be contrasting incipient SB and destructive SB; the same two photomicrographs in IV are used to contrast a device destroyed under d.c. operations with that destroyed in r.f. operation. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

I. 65A22183
TITLE: An appraisal of transistor thermal resistance measurement techniques
SOURCE: Semiconductor Products and Solid State Technology, vol. 8, Apr 65, p. 21, 22, 27-29

...

II. 65A29400
TITLE: An explanation of the "energy" dependence of secondary breakdown in transistors
SOURCE: Proceedings of the IEEE, vol. 53, p. 624, Jun 65 (correspondence)

...

III. G
TITLE: New aspects of second breakdown in transistors
SOURCE: solid/state/design, vol. 5, Apr 64, p. 23-27

...

IV. 64N24944
TITLE: Transistor characterization and derating for second breakdown
SOURCE: solid/state/design, vol. 5, May 64, p. 24-28 (also NASA accession number N64-24944; AD-600 142)

...

V. 64N20334 64A16936
TITLE: Bulk reliability effects in semiconductor devices; current crowding in transistors
SOURCE: Semiconductor Products and Solid State Technology, vol. 7, Apr 64, p. 23-28 (also NASA accession number N64-20334; AD-408 131)

...

VI. G
TITLE: Maximum collector voltage and secondary breakdown in transistors
SOURCE: IEEE Transactions on Electron Devices, vol. ED-11, p. 122, Mar 64

...

AUTHORS: Bernard Reich and Edward B. Hakim (*U. S. Army Electronics Laboratory, Fort Monmouth, N. J.) (I, II, IV, V, VI)
Bernard Reich (*) (III)

...

PURPOSE: To describe methods of measuring the thermal resistance of transistors (I, II); to discuss the correlations between thermal resistance measurements and the incidence of second breakdown (III-VI).

ABSTRACT: I. Mil-Std-750 describes three temperature sensitive parameters which can be used in the pulsed measurement of thermal resistance: (1) collector-base cut-off current; (2) forward voltage drop of the emitter-base diode; (3) forward voltage drop of the collector-base diode. Because of failure to specify the method/conditions of measurement or choice of the wrong method, highly optimistic values of thermal resistance typically are quoted by manufacturers--values which cannot be correlated with other trans-

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

istor properties. Two continuous methods of measuring thermal resistance utilize V_{BE} and h_{FE} as the temperature sensitive parameters. Sources of error and methods of cross-check are described; operating biases must be specified in order to report meaningful data. Continuous methods of measuring thermal resistance yield values closer to those deduced from storage and operating life tests.

II. The thermal resistance of a transistor can be determined by pulsing it in the open base avalanche mode. After the initial breakdown, the observed I-V characteristic exhibits a second peak which corresponds to the temperature at which the collector resistivity is maximum. Knowing this temperature, the ambient temperature and the power input at this second peak, a value of thermal resistance can be calculated. This value depends upon pulse width ("the time the collector-emitter voltage remains at the maximum value"), particularly for pulse widths less than 1 ms. At pulse widths greater than 1 ms, the thermal resistance becomes relatively constant. Hot spot temperatures just prior to second breakdown (SB) were calculated to be 525-550°C, using the values of thermal resistance computed by this method.

III-VI. Transistor SB in either the current mode or the voltage mode is preceded by an exponential rise in the thermal resistance, θ, the ratio of increase in junction temperature to power input, of the transistor. Equations describing the observed behavior of thermal resistance with increasing collector current I or increasing collector-base voltage V are of the forms

$$\theta = \theta_o \exp[k(I-I_o)] \text{ and } \theta = \theta_o \exp[C(V-V_o)]$$

where θ_o = the thermal resistance at $I \leq I_o$ or $V \leq V_o$,
k = the current crowding factor (slope of θ vs I_c),
C = a constant, and
$I_o(V_o)$ = the value of collector current (collector-base voltage) at which the exponential rise of thermal resistance begins.

The larger the values of k or C, the quicker the onset of SB.

The same k fits the exponential fall-off of current gain with collector current: $h_{fe_1}/h_{fe_2} = \exp[-k(I_2-I_1)]$, where h_{fe_1}, h_{fe_2} are the low-frequency current-gains at collector currents of I_1 and I_2. The factors which minimize the decrease of current gain with collector current also reduce transistor susceptibility to SB.

The coefficient C is influenced by the variation of the width of collector-base depletion region with V_{CB}. Curves of capacitance

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

vs V_{CB} for junctions of transistors with non-uniform collector doping such as epitaxial or triple diffused transistors display breaks at $V_{CB} \sim V_o$. Beyond this value (or I_o) thermal derating of the transistor is advisable. Other conclusions include the following:

(1) SB occurs not only in transistors but also in the diodes of the device, as well as in most other junction diodes.

(2) SB, as it occurs in the collector-base diode, affects the collector emitter characteristic in that premature breakdown can occur under shorted or reverse base current drive conditions. To overcome this condition, the device should be designed so that the "punch-through" voltage is less than the collector-base breakdown voltage. If punch-through occurs prior to collector-base breakdown, the effect of base bias on the devices' SB characteristics is minimized if not completely eliminated.

(3) Secondary breakdown spot temperatures are calculated to be between 900-1100°C in silicon. (Authors in part)

REVIEW: The use of transistor thermal resistance measurements to study SB performance seems to be a very direct and profitable approach in a field beset with experimental complexities. The correlations observed would seem to confirm the thermal origin of SB quite neatly. The major strength of the papers rests with the practical correlations reported between SB and other non-destructive measurements (such as thermal resistance) rather than with any insight into the SB mechanism. The presentations are a sequential listing of interesting, seemingly related observations but the unity among the various points is not always emphasized.

Papers III and IV appear to have been written independently and later coupled to form a two-part series. Discussion of identical topics differs in the two parts. The low current dependence of θ upon I_c in III (Fig. 4) is depicted differently than in IV (Fig. 3). The concept of "infinite" thermal resistance, presented in III, is not mentioned in IV. Is it then significant after all?

There are minor editorial inadequacies--units of thermal resistance are omitted in III until the examples at the end of the paper; equation 8 in IV is erroneously cited as derived in III (actually it is in V); at one time or another the letter C is used as a slope (see ABSTRACT), to indicate degrees Celsius, as a symbol of capacitance, and as the reciprocal of an empirical thermal runaway coefficient. Equation 2 in II probably should read $T_{js} = \theta_t(V_s \times I_s) + T_a$ rather than $...\theta_t(V_s, I_s)$; all factors in equation 3 are undefined in II. The work, undeniably worthwhile, might have been more effectively presented in a single painstakingly prepared paper rather than in a series of short publications. ##

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65 N11608

Serial Number 2185
ASQC Codes 713;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An analysis of creep rupture

AUTHOR: Robert L. Carlson (Stanford University, Department of Aeronautics and Astronautics, Stanford, Calif.)

SOURCE: Technical Report No. 5, prepared for the Office of Naval Research of the U. S. Navy under Contract Nonr-225(47), Project NR 064-434, Feb 64, SUDAER No. 183, 13p, 20 refs. (AD-606 081; NASA accession number N65-11608; OTS $1.00)

PURPOSE: To present an analysis of ductile creep-rupture.

ABSTRACT: A discussion of ductile creep-rupture is presented, based on time-independent inelastic deformation of a work hardening material which is subject to creep. A brief outline of the theory of tensile instability is included because of its relation to the onset of necking. A method for performing ductile creep-rupture computations is presented.

The true stress acting on a creep specimen which is subjected to a constant tensile load increases and the rate of work hardening decreases. When the rate of work hardening is equal to the true stress, tensile instability develops. Tensile instability can develop at a finite strain, and it is indicated that the plastic strain response influences the onset of localized necking. It appears likely that the mechanics of creep instability in biaxial stress fields requires a consideration of plastic properties. Mechanics of tensile creep instability and necking possess common features with the mechanics of compressive creep instability and buckling. Plastic properties or the work hardening characteristics play an important role in determining the capacity of structural elements which are subjected to creep.

REVIEW: The paper is not for the beginner; and, in the absence of the several references, it is somewhat difficult to comprehend and follow. The paper is, however, a worthwhile addition to creep-rupture literature. The results of this work may be useful to the design engineer, but experimental verification would increase the confidence in the proposed theory. ##

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64N12901

Serial Number 2186
ASQC Codes 712;773;782

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Development of an apparatus for fatigue testing in vacuum

AUTHOR: R. P. Felgar (Space Technology Laboratories, Inc., Redondo Beach, Calif.)

SOURCE: Report EM 13-11; 9990-6419-KU000, Engineering Mechanics Laboratory, Space Technology Laboratories, Inc., Redondo Beach, Calif., 10 May 63, 35p (NASA accession number N64-12901)

PURPOSE: To report the development of a small fatigue apparatus, along with the design and fabrication of an appropriate specimen, for fatigue in space tests.

ABSTRACT: This fatigue tester must be suitable for use in a satellite. Such a device requires small size and weight, low power, output signal compatible with standard telemetry circuits, automatic control of cyclic stress or strain amplitude, provision for initiating the test by radio signal, and use of materials which do not out-gas under vacuum.

A battery powered electromagnetic vibrating apparatus was designed, built, and calibrated. The small specimens, in the shape of a tuning fork, are driven by the vibrator at resonance. A feedback circuit to maintain constant vibration amplitude and to indicate fatigue cracking is included in the design for satellite use. The flight package containing six specimens is expected to have the following characteristics:

Weight	-	One pound, with aluminum specimens
Volume	-	Fifteen cubic inches
Power	-	1.3 watts during testing
Frequency	-	500 cps specimen vibration

The apparatus performed satisfactorily in vacuum, and a limited number of fatigue tests on 7075-T6 aluminum in air and in vacuum (approximately 10^{-8} torr) show that (1) the vacuum increases the mean fatigue life by a factor of 13, and (2) based on 95% tolerance limits, the vacuum increases fatigue life by a factor 1.8.

REVIEW: This report is well written and easy to read, and the author has covered all aspects of his work in considerable detail. But, because of the apparatus which is described, the report is most probably not for general reading.

The fatigue data comparing 7075-T6 aluminum tested in air and vacuum environments may be useful to the design engineer, particularly the design engineer or materials engineer in the aerospace industry. ##

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64N30118

Serial Number 2187
ASQC Codes 716;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Engineering survey of aircraft structural failures caused by corrosion, fatigue, and abrasion

AUTHORS: --

SOURCE: TRECOM Technical Report 64-36, prepared by University of Oklahoma Research Institute, Norman, Okla., for U. S. Army Transportation Research Command, Fort Eustis, Va., Task 1D121401A14203, Contract DA44-177-AMC-98(T), Jul 64, 29p (AD-605 325; NASA accession number N64-30118)

PURPOSE: To report on a survey of Army aircraft structural failures caused by abrasion, corrosion, and fatigue in order to define critical areas of future structural research.

ABSTRACT: The data for the survey were obtained from Army failure reports, "Equipment Improvement Recommendations", for four helicopters (UH-1, CH-13, UH-19, and CH-34) and two fixed-wing aircraft (U-6 and O-1) for the period 1 Jan 63 to 31 Aug 63. Approximately 2300 relevant EIR reports from the U. S. Army Aviation and Materiel Command, St. Louis, Missouri, were read in detail, but only 463 of the reports yielded pertinent information. Four significant problem areas are: (1) corrosion and fatigue of primary airframe structures, (2) separation of rotor blade metal bonded joints, (3) erosion of rotor blade leading edges, and (4) sustained rotor blade balance. A search of the 1963 DDC indexes indicates that only one problem area--rotor blade dents and leading edge erosion--is receiving the necessary consideration. Major recommendations for future consideration are:

1. Research into the use of fiberglass-reinforced plastic material for primary airframe structures.
2. A study of rotor blade bonding separation.
3. A continued search for protective materials and the development of new materials of construction for the solution of the problem of rotor blade damage during operation.
4. Nonperforated or sealed honeycomb core material for use in rotor blade construction.

REVIEW: This report, although not highly technical, is most informative; it is recommended reading for design engineers in the aircraft field. The approach of thoroughly defining the frequency and severity of a problem before undertaking its solution has considerable merit. This work should be continued so that future R&D expenditures will be commensurate with the problems encountered. The inadequacies of field failure reporting are implicitly represented in the problems of getting adequate data. A simple punched card data collection system was designed by the authors, and is included as an appendix to the report, but its effectiveness is not known. ##

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65N17357

Serial Number 2188
ASQC Codes 712;713

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Theory of the accumulation of fatigue damage during an asymmetrical cycle of random stresses

AUTHOR: V. F. Shukailo

SOURCE: Izvestiya Vysshikh Uchebnykh Zavendeniye Mashinostroyeniye, SSSR, Nr. 12, 1962, p. 21-32, Translation prepared by Translation Division, Foreign Technology Division, WP-AFB, O., FTD-MT-63-115, 26 Dec 63 (AD-605 882; NASA accession number N65-17357; OTS $1.00)

PURPOSE: To present general formulas for the accumulation of fatigue damage during an asymmetrical cycle of random stress.

ABSTRACT: General formulas and the upper and lower limits of durability are presented based on linear and nonlinear theories of accumulation of fatigue damage for a load specified in general terms. The load is represented as some stationary random function of time for which the mean value is not zero. Stress changes are divided into cycles which are defined as the time intervals along the stress curve between two adjacent intersections of the average stress, from below upwards. A cycle is defined as simple if it contains a single pair of extreme values and complex if it contains more than a single pair of extreme values. The probability of forming a cycle having pairs of extreme values larger than some arbitrary number N was evaluated and was found to diminish, with an increase in N, according to a hyperbolic law.

Strict and successive application of the linear law of fatigue damage accumulation is dangerous because it will always result in an overestimate of the load capacity of a structure (extreme value of durability); therefore, it is always necessary to introduce a safety factor for design purposes. The formation of complex stress cycles in a stationary random process of stress change is small, and it is possible to calculate durability from a simplified formula. If, however, the amplitude-frequency characteristic of the structure has a pronounced maximum at a certain frequency, the calculation of durability becomes somewhat more complex.

REVIEW: This document is a machine translation of Russian text and it is very difficult to follow and comprehend. Some of the difficulties of the paper result from incorrect word order in sentences, which has been partially corrected. The remaining difficulties are caused by the purely mathematical approach taken by the author.

The paper may be of considerable value but probably not to the design engineer, because of the complexity of the mathematics. The assertion about linear damage accumulation always overpredicting load capability is not accurate. ##

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64N15573

Serial Number 2189
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Materials - 7075-T6 aluminum alloy - cumulative damage effects - investigation of -

AUTHOR: --

SOURCE: FTDM-2892, Published and distributed under Contract No. AF33(657)-11214, Air Force Materials Laboratory, Aeronautical Systems Division, Air Force Systems Command, Wright-Patterson Air Force Base, O., by General Dynamics/Fort Worth, 15 Jan 64, 22p (AD-430 152)

PURPOSE: To present empirical fatigue data for use in evaluating methods of assessing cumulative damage.

ABSTRACT: Specimens machined from a single one inch thick plate of 7075-T6 aluminum alloy were tensile tested and fatigue tested. High speed fatigue was conducted at 1800 cpm on either a Sonntag SF-1U or IV-4 test machine. Slow speed fatigue tests were made on modified Arcweld creep test machines at 15 cpm. The fatigue tests were conducted under a variety of load spectra in order to evaluate (1) the threshold of damage, (2) effect of stress level and order of applying the load, and (3) the effect of spectrum size on both smooth and notched specimens (notch ratio of one).

Certain loading spectra appear to increase fatigue life while others appear to reduce fatigue life. In general, the loading sequences appear to affect fatigue life of the notched specimens more than the smooth specimens. The low to high order of load application was more detrimental to specimen fatigue life in all cases than the high to low order of loading. The half spectrum and the double spectrum reduced the fatigue life of the smooth specimen and the notched specimen, respectively.

REVIEW: The test program appears to have been well planned. The specimens were selected at random and all tests were replicated; but the data are not analyzed statistically. Instead, the data are presented and discussed based on average values. Individual data points are tabulated in the report so that statistical analyses could be accomplished.

The report is primarily a collection and presentation of data, which is exactly what the authors set out to do, it is probably not useful to design engineers. ##

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64N30061

Serial Number 2190
ASQC Codes 713;716

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An investigation of material parameters influencing creep and fatigue life in filament wound laminates

AUTHORS: R. H. Cornish, B. W. Abbott and C. K. Cole (IIT Research Institute Technology Center, Chicago, Ill. 60616)

SOURCE: Final Report, IITRI Project No. M251, prepared by IIT Research Institute for Bureau of Ships, Department of the Navy, Code 634C, Washington 25, D. C. under Contract No. NObs86461, May 64, 48p (AD-602 495; NASA accession number N64-30061)

PURPOSE: To report biaxial compressive fatigue and creep (stress-rupture) performance of glass reinforced plastics in wet and dry environments.

ABSTRACT: Biaxial hydrostatic fatigue tests at 200 cph and biaxial stress-rupture tests were conducted in wet and dry environments on hollow cylindrical specimens of glass reinforced plastics (GRP) having 20% and 26% resin content. Complete details of specimen preparations and test procedures are presented. Resin content, density determination, ultrasonic flaw detection, residual stresses, and microscopic examination of winding patterns are considered. The fatigue test data were grouped so that meaningful statistical analyses could be conducted. The 20% resin material is completely satisfactory in resin content and material density, and it is more amenable than the 26% material to quality control. Correlation of size and location of flaws, as detected by ultrasonics, with points of failure has considerable promise. Residual strain measurements on ring specimens indicate residual compressive stresses at the O.D. and residual tensile stresses at the I.D as high as 10 ksi.

There were no statistically significant differences between the fatigue performance of the 20% and 26% resin materials in wet or dry environments. Furthermore, the wet and dry environmental test conditions did not influence the fatigue performance of either material. The 20% resin material, based on limited data, demonstrated slightly better low cycle fatigue performance than the 26% material. The endurance limit was estimated to be 60 ksi at 10,000 cycles for both materials.

No significant long-term deformation or failures resulted from stress-rupture tests which were in progress up to 14 months; therefore, endurance limit appears to be the critical factor governing the structural performance of tube specimens of GRP.

REVIEW: This report is recommended reference material for design engineers using glass reinforced plastic materials. It is thorough, well organized, and easy to read. The data were analyzed by "approximate" statistical techniques. ##

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Serial Number 2191
ASQC Codes 712;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Application of cumulative fatigue damage theory to farm and construction equipment

AUTHOR: H. T. Corten (University of Illinois)

SOURCE: Presented at the National Farm Construction and Industrial Machinery Meeting, Milwaukee, Wis., 9-12 Sep 63, SAE paper 735A, 20p, 26 refs. (Society of Automotive Engineers, Inc., 485 Lexington Avenue, New York 17, N. Y.)

PURPOSE: To present ways of estimating the fatigue life of farm and construction equipment from known service loads and S-N data.

ABSTRACT: Emphasis is placed on large vehicles which are made from structural steel and fabricated by welding such as a scraper frame. The methods of analysis are generally applicable to metal components which are subjected to a spectrum of loads; however, the details differ depending on material, method of fabrication, load history, number of load sources, and nature of load. Estimation of fatigue life involves three primary factors--stress spectrum, fatigue characteristics of the structure (constant amplitude S-N relation), and a cumulative damage expression for relating the first two elements. In this particular case, cumulative damage is assessed, assuming a linear accumulation of damage and an S-N relation of the form $N \propto S^d$, where d is a constant. A sample computation for determining fatigue life is included. Questions and uncertainties are analyzed concerning (1) terms in the cumulative damage equation, (2) determination of load spectrum, (3) flaws and cracks in the weld area, (4) crack initiation and propagation, (5) static strength of a fatigue cracked structure, and (6) chance peak loads. In general, the problem of crack initiation appears to be secondary because of the probability of the existence of a flaw of critical size in the weld area. A reasonable estimate of the highest stress accounted for in the analysis can be obtained from the peak load cycles comprising 0.1 per cent to 1 per cent of the spectrum. It is evident that scatter in life is influenced by the size of the vehicle, the severity of service, rare overloads, and the probability and distribution of flaws in the weld area.

REVIEW: In this paper the author has analyzed the problem, developed theories, and presented the mathematics for each phase or step of the solution. The paper is recommended reading and reference material for the design engineer. While some of the author's assumptions, estimates or theories may be questioned, his completeness in handling the problem makes the paper most valuable. There are some minor typographical errors (for example in Equation 6 the symbol d should be a superscript), but they do not detract from the paper. ##

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63N21169

Serial Number 2192 -1
ASQC Code 712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Review and analysis of cumulative-fatigue-damage theories

AUTHOR: Lloyd Kaechele (The RAND Corporation, Santa Monica, Calif.)

SOURCE: RAND Corporation Memorandum RM-3650-PR, prepared for USAF Project Rand, Aug 63, 82p, 14 refs. (AD-416 640; NASA accession number N63-21169).

PURPOSE: To present basic concepts of cumulative damage and evaluate several cumulative-fatigue-damage theories.

ABSTRACT: A general discussion related to the design of fatigue-resistant flight structures is presented. Questions concerning fatigue damage--what it is, how it is measured, and how it progresses, as a result of stress variations--are included.

Cumulative-fatigue-damage theories postulate the form of damage growth and state the rules for adding the damage produced by the various stress cycles. In general, cumulative damage theories can be categorized based on the way fatigue damage is assumed to occur when different stress amplitudes are applied alone or mixed with other stress amplitudes. In terms of these assumptions, cumulative damage theories are:

1. Stress-dependent or stress-independent, and
2. Interaction or interaction-free theories.

Current cumulative damage theories considered to have potential for aircraft design are examined and compared in terms of predictions of fatigue life under spectrum loading. The basis of comparison, because of simplicity and familiarity, is Miner's Theory. Life prediction is an intermediate step in this study because the important differences in the theories are not differences in life, but differences in the amount of material required for a specified life. Miner's Theory states that fatigue failure will occur when the fractions of life expended at each stress amplitude total to unity. Miner's Theory is a stress-independent interaction-free theory, and other theories that have these features are equivalent to Miner's Theory. Stress-dependent, interaction-free theories, when applied to aircraft design, will result in heavier structures than those predicted by Miner's Theory. Interaction effects can lead to designs either heavier or lighter than a design based on Miner's Theory. The theories considered are:

Valluri's Theory - based on dislocations and plastic deformation at the tip of the crack. It is equivalent to Miner's Theory if certain restrictions in the definition of fatigue damage are observed.

Grover's Theory - postulates a two stage fatigue damage process. It will lead to increased structural weight, compared to the predictions of Miner's Theory (unless the fractional life at the transition between stages is the same at all stress levels).

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Corten-Dolan Theory - includes interaction effects. It agrees with some experimental evidence, but so does Miner's Theory.
Freudenthal-Heller Theory - an interaction theory based on a fictitious S-N curve and the application of Miner's Theory to the curve.
Shanley's Theory - proposes interaction effects which result from variable initial damage. It would lead to a heavier design than Miner's Theory.
2-x Method - an interpretation of Shanley's original theory, and interaction effects are included. The 2-x method would predict greater structural weight than Miner's Theory.

Study of how these theories would be applied exposes their limitations and the need for experimental work to establish their usefulness. Microscopic observation techniques may offer opportunities for important advances in the study of damage. There do not appear to be any radical "breakthroughs" in the physical understanding or theoretical techniques of cumulative-fatigue-damage evaluation. Spectrum testing remains a vital ingredient in the design of fatigue-resistant aircraft structures; until a sound physical basis is established, cumulative damage evaluation must depend on unproved models.

REVIEW: This paper is well written and most informative. It should be of considerable value to reseachers and design engineers concerned with cumulative-fatigue-damage, particularly those in the aircraft industry. It should be noted that there is not universal agreement on whether or not a theory is supported by data. Miner's Theory for example predicts life correctly sometimes, and is too short or too long for other data. The memorandum should be especially useful as reference material for the beginner. ##

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64 N28914

Serial Number 2193 -1
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Simultaneous application of static and dynamic loads on sonic fatigue test articles

AUTHORS: W. H. Roberts and D. P. Wilhelm (Northrop Corporation, Norair Div., Hawthorne, Calif.)

SOURCE: Technical Documentary Report No. RTD-TDR-63-4021, Air Force Flight Dynamics Laboratory, Research and Technology Division, AFSC, Wright-Patterson AFB, Ohio, prepared under Contract No. AF33(657)-8759 by Northrop Norair, A Division of Northrop Corporation, Hawthorne, California, Jun 64, 111p, 18 refs. (AD-604 407; NASA accession number N64-28914)

PURPOSE: To describe an investigation to determine the effect of combined loading on the fatigue life of aircraft and missile structures.

ABSTRACT: By discussing individual cases of the B-58, the T-38 Supersonic jet trainer, the Mercury capsule, etc., the tentative conclusion was reached that combined load studies are of the utmost importance whenever acoustic, aerodynamic, static, dynamic and thermal loads occur simultaneously. Stresses measured near failure points are in the 1,000-2,000 psi range whereas the endurance limit is 4,000 psi. This is an indication of the presence of other loads that were not considered. Also in the case of the B-58 during tests simulating oscillation from after-burner operation in the presence of high acoustic field (168 db on the wing), a number of failures were observed during the 10-hour sonic fatigue test, yet in production more extensive failures resulted. This also indicates that some load omitted during the test proved quite destructive. The significance of these combined loads becomes even greater because materials show considerable difference in their ability to withstand random loading. This is substantiated by the fact that steel showed a minimum cumulative damage fraction of 0.1 while aluminum showed approximately 0.2; this difference could become more pronounced as new materials are introduced.

From a cumulative damage fraction study the authors established that:

1. Cumulative damage is about 0.1.
2. The random endurance limit is less than the normal endurance limit.
3. The remaining strength continuously decreases with damage accumulation.

The probability of failure increases sharply in the early life of the component. By adding an acoustic load the probability of failure for a 22,500 psi maneuver stress and 8,000 psi acoustic stress becomes 0.1 after 20% of the total life and 0.5 after 50%.

Some of the examples are:

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1. Engine air inlet duct.
In this case the most severe operational conditions contributing to failure are those of engine ground operations. The loads that must be simulated are air turbulence, engine vibration, and acoustic loading due to compressor whine.
2. Afterburner transient and mechanically transmitted thrust oscillation.
An excessive number of failures during a test on the B-58 aircraft were attributed to thrust variation caused by afterburner transient, mechanically transmitted thrust oscillation, engine vibration and acoustic energy from engine exhaust.
3. Primary structural qualification.
The loads that are essential and need to be simulated in testing of primary structures are:
a. Loads causing flexure torsion and shear.
b. Conventional loads at the wheels which are transmitted by the gear to the primary members supporting the gear.
c. Acoustic loading due to engine noise.
d. In some cases vibration loads are significant and should also be simulated when certain structures are tested.
4. Missile static fire-ups.
In testing the structural integrity of missiles or upper stages, vibration appears to be of primary concern and random vibration from 0 to 1000 cps is one of the loads that must be simulated. The large siren bank of the RTD facility is used to simulate the acoustic gradients over the height of the missile (148-155 db). Simulation of thermal loading and other loading due to the pressurized liquid (-200 to 400^{o}F) is limited because of the hazard involved.

After discussing the ways by which each of the loads will be simulated for a total of seven cases, some alternate loading methods and their merits are discussed briefly.

REVIEW: The authors bring to attention the importance of combined loading because of the interactions between static and dynamic loadings. Yet this conclusion is "tentative" which means that additional data must be needed. Enough evidence is given to demonstrate the merit of additional efforts in that direction. The RTD sonic facility appears very well equipped to provide additional information.

The definitions of the major types of loading are quite clear and helpful in understanding the rest of the paper. Appendix A on "limiting phenomena for fatigue crack failures" is very informative while Appendix B is of more academic interest. Appendix C does exactly what the authors intended. It demonstrates the complexity involved in obtaining required probability density functions. ##

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Serial Number 2194 -1
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Methods of predicting and/or improving materials fatigue life

AUTHOR: R. L. Jones (General Dynamics/Fort Worth)

SOURCE: Report No. FGT-2096, published and distributed under Contract AF33(657)-7248 by General Dynamics/Fort Worth, 24 Oct 62, 63p, 13 refs. (AD-287 819)

PURPOSE: To evaluate methods of predicting and improving fatigue life.

ABSTRACT: This paper covers five separate investigations made to evaluate methods of predicting and/or improving fatigue life. These include:

- Phase I - Radioactive isotopes to detect fatigue cracks
- Phase II - Removal or fatigue damaged surfaces by machining, electropolishing, dynamic etching, and shot peening to determine the effect on cumulative fatigue life
- Phase III - Fatigue properties of vacuum-melted SAE 4340 steel at 260 to 280 ksi
- Phase IV - Mechanical and fatigue properties of nitralloy 135 having an ultimate tensile strength of 150 ksi
- Phase V - Use of ultrasonics for detecting fatigue cracks.

In Phase I specimens with visible cracks were soaked in a radioactive solution for various periods, then wiped dry and wrapped with badge film for various exposure times. In every case the amount of solution collected in the crack was insufficient to overcome the background radiation from the area surrounding the crack. As a result the idea was dismissed as being unsatisfactory.

Phase II tests were made to determine if the fatigue life could be restored by removing surface cracks by the methods previously outlined. All tests were made on R.R. Moore Rotating Beam Test Machines. Machining 10 mils from the surface, after 60% of the expected life obtained from tests on reference specimens, showed improvements of 95%, 139% and 262% at alternating stress levels of 100, 80, and 75 ksi respectively. A second machining of 10 mils from the surface at 60% of the remaining life led to further increases of 23%, 42%, and 57% for the same stress levels in the order previously given. The lower improvement for the second machining was attributed to a failure to remove all surface cracks. Surface removal by etching caused a reduction in life. Electropolishing gave a slight improvement but not as much as obtained from machining. Shot peening did not result in surface removal but did provide beneficial surface compressive residual stresses. The "healing" effect of shot peening specimens prior-tested to

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60% of the expected fatigue life also helped to restore fatigue life but again not to the extent of machining or electropolishing.

Phase III tests on vacuum melted vs. airmelted SAE 4340 steel specimens, both notched and unnotched, show that some benefit is derived from vacuum melting at the higher stress levels. The endurance limit (10^7 cycles) for unnotched specimens was about 15 ksi higher for the vacuum melted steel than for the airmelted steel which had an endurance limit of near 112 ksi.

Phase IV tests were made to determine the static and dynamic properties of nitrided nitralloy 135 modified. The specimens were austenitized at 1700°F for 1/2 hour and oil quenched; then tempered at 1200°F for one hour. Nitriding consisted of holding the parts for 48 hours at 975°F in ammonia atmosphere. Types of specimens included tensile, notch tensile, Izod and R. R. Moore notched and unnotched. When compared to the base metal, the nitrided nitralloy shows a 40% increase in fatigue at the endurance limit; has reduced ductility and impact strength; and has fatigue properties which are superior to SAE 4130 for the same ultimate tensile strength.

Phase V tests investigated the use of ultrasonics for detecting fatigue cracks. The method employed was found to be very sensitive and permits monitoring during running of a specimen. The technique is more sensitive than dye penetrant since it locates surface cracks at the point when they first become visible. A continuously monitoring, ultrasonic surface search unit was capable of detecting fatigue cracks by as much as 10,000 cycles before a dye penetrant method was effective.

REVIEW: The paper handles the subject matter very well and is not overly detailed. Some interesting ideas are obtained in the Phase II tests dealing with restoring the fatigue life of specimens using surface removal techniques. Of further interest would have been how the depth of the material to be removed from the surface is determined in order to eliminate existing surface cracks. ##

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64N14468

Serial Number 2195
ASQC Codes 711;712;782;
844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Creep fatigue interacting under cyclic loading conditions

AUTHOR: B. J. Lazan (University of Minnesota, Minneapolis, Minn.)

SOURCE: Technical Documentary Report No. ASD-TDR 63-644, prepared by the University of Minnesota, Department of Aeronautics and Engineering Mechanics under USAF Contract No. AF33(657)-7453, Project No. 7351, May 64, 46p, 52 refs. (AD-425 551; NASA accession number N64-14468)

PURPOSE: To explain the role of synergistic phenomena on creep and strength properties under variable stress and temperature conditions.

ABSTRACT: The term "synergistic" is used to describe material behaviors such as strain, flow, and hardening which occur when interaction exists between different stimuli. The presence of these synergistic phenomena seriously limits the use of superposition for load and environmental analysis. To avoid a lengthy test program, and by being aware of the synergisms involved, one may group the variables into combinations within which there are no interactions. Considerable elaboration is given to the mechanisms of deformation and failure under (1) static load, which leads to creep and stress rupture, (2) reversed load, causing pure fatigue, and (3) combined loading, producing both dynamic creep and fatigue damage. Low cycle fatigue is characterized by increased hardness and internal stress, which are also characteristic of static fracture; it is therefore referred to as a region of delayed static fracture. The slip growth and microstructural deterioration apparent in high cycle fatigue are thoroughly discussed.

Analytical methods for predicting dynamic creep from static creep data are presented and compared with actual test results. A reasonably good correlation exists between theoretical curves and creep rates obtained on mild steel at 400°C. However, the behavior of "superalloys" at high temperatures deviates seriously from the model. Some reasons for these deviations are explained, but it appears that for the foreseeable future the main source of reliable data on these alloys will be actual laboratory tests. In further consideration of creep at combined static mean stress and cyclic loads, significant creep was found to occur at a mean stress of less than 10% of the yield strength of the material. The effects of temperature on fatigue and creep-rupture strengths and the synergisms associated with variable temperature are also discussed.

REVIEW: This paper covers a broad scope of fatigue interaction phenomena. It should be of particular interest to designers of aerospace structures especially where complex environments and interactions are involved. Many references are given. ##

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64N10170

Serial Number 2196
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The fatigue strength of members containing cracks

AUTHORS: W. J. O'Donnell and C. M. Purdy (Westinghouse Bettis Atomic Power Laboratory, Pittsburgh, Pa.)

SOURCE: Presented at the Petroleum Division Conference, Tulsa, Okla., Sep 63, 36p, 20 refs. (NASA accession number N64-10170)

PURPOSE: To discuss the prediction of fatigue life of members containing crack-like defects.

ABSTRACT: A finite volume of material must be stressed to the endurance limit in order to cause failure. This leads to the hypothesis that the stress value which limits fatigue lies at some distance δ below the surface. δ is assumed to be a property of the material and independent of specimen size. Relationships are given for δ as a function of the tensile strength of steels. The fatigue notch factor therefore equals the ratio of the stress at a distance δ from the surface of the notch to the nominal stress in the net cross section. Using Neuber's Equations, fatigue notch factors were obtained for a δ-value of 2 mils, corresponding to quenched and tempered 100,000 psi tensile strength steels. Of course these values may safely be used for lower strength steels, aluminum and other materials which are less sensitive to notches.

Fatigue notch factors were obtained as a function of the root radius section width, crack depth, and type of loading (i.e., bending or tension). The analysis showed that:

(1) Fatigue notch factors for cracks do not vary appreciably over the range of root radii up to about 10 mils.

(2) Fatigue notch factors for bending and tension are identical for very shallow cracks. For deeper cracks, the bending notch factors are lower than the tensile factors (for tension with a resultant at the center of the net section).

(3) Fatigue notch factors are higher for geometrically similar thicker sections. This is the well known size effect.

The paper points out that validation of the δ concept has been based on tests made using notches rather than cracks. However, the authors have reported that preliminary results from subsequent fatigue tests on cracked specimens agree well with the theory.

REVIEW: The authors have made a good presentation of a concept which should be of interest to those engaged in fatigue or stress analysis work. Additional experimental research appears necessary to verify some of the conclusions reached. If the δ concept is validated for cracks, the problem of selecting notch factors may be simplified by the selection of "worst case" values without undue conservatism. The paper is well written and adequately documented. ##

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9/65 64X12664 Serial Number 2197
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An investigation of the fatigue behavior of tantalum including the effect of strain aging

AUTHOR: D. Y. Wang (Air Force Systems Command, Research and Technology Division, Air Force Materials Laboratory, Wright-Patterson AFB, O.)

SOURCE: Technical Documentary Report No. RTD-TDR-63-4224, Air Force Materials Laboratory, Research and Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, O., Project No. 7351, Task No. 735106, Jan 64, 27p, 24 refs. (AD-431 192)

PURPOSE: To describe an investigation of the fatigue behavior of tantalum.

ABSTRACT: The presence of any fatigue limit is due to strain aging under alternating stress rather than being an intrinsic property of metals. The shape of the fatigue curve, the fatigue limit, and the knee of the fatigue curve are functions of strain aging variables, temperature, and the interstitial content of the metal. A reduction of the interstitial element content results in a decrease in the fatigue limit and in a shift of the knee to a higher value of cycles. An increase in temperature increases the mobility of interstitial atoms in diffusion and causes the knee to occur at a lower life. The strain aging effect is also dependent on the quantity of dislocations produced in the region of the advancing crack and on the rate of diffusion of the pinning atoms. To verify these theories, tests were made on commercially pure arc melted tantalum. The three groups tested were "as-received," vacuum annealed at 1650°C, vacuum annealed at 2320°C. All groups varied in the amount of interstitial elements. The effect of temperature on the shape of the fatigue curve was established from tests at room temperature and at 288°C on the 1650°C annealed specimens. These showed a significant difference in the fatigue limit and in the location of the knee as predicted by the theory. A comparison of room temperature tests on both 1650°C and 2320°C annealed groups show a difference in the fatigue limit; however the large difference in the interstitial content between the 1650°C and 2320°C groups did not result in a shift in the knee as expected. This failure is attributed to a difference in grain size and to material softening. Tests on the "as received" group, which had the highest number of interstitials, showed the highest fatigue limit and the lowest value of cycles at the knee. Tests were also made which indicated that coaxing contributed substantially to increasing the fatigue strength.

REVIEW: The model explains why certain materials have a fatigue limit and why there are differences in the shape of S-N curves. The subject of strain aging is very well treated and the results are clearly presented. Some familiarity with dislocation and slip plane theory is required to understand the paper. ##

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64N11818

Serial Number 2198
ASQC Codes 711;782

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Determination of low-temperature fatigue properties of aluminum and titanium alloys, annual summary report

AUTHORS: F. R. Schwartzberg, R. D. Keys, M. J. Brown, and C. L. Reightler (Martin-Marietta Corporation, Aerospace Division, Denver, Colo.)

SOURCE: NASA-CR-63-29, prepared by Martin-Marietta Corporation under Contract NAS8-2631 for the George C. Marshall Space Flight Center, NASA, Jul 63, 116p, 10 refs. (NASA accession number N64-11818)

PURPOSE: To describe progress on a program to determine the low-temperature fatigue behavior of aluminum and titanium alloys.

ABSTRACT: The use of cryogenic propellants for booster and space vehicle systems has emphasized a need for tensile and fatigue data at extremely low temperatures. Cryogenic literature is virtually non existent for cyclic loading particularly on welded material. This paper covers tensile and fatigue tests made at 70°, -320°, and -423°F on the following sheet alloys: Aluminum: 2014-T6, 2219-T87, 5456-H343, 2020-T6, and 7075-T6; Titanium: Ti-5Al-2.5 Sn, Ti-6Al-4V, and Ti-13V-11Cr-3Al.

Ultimate strength, yield strength, elongation, and weld strength where welds existed were recorded. The fatigue/ultimate strength ratio and the fatigue/yield strength ratio were determined for both parent metal and welded groups at 70°, -320°, and -423°F and at 10^3, 10^4, 10^6 and 10^7 cycles. In nearly all cases the tensile and fatigue strength increased with a decrease in temperature.

In general, little difference was found in the endurance limit of any of the aluminum alloys. The weldable alloys, 2014-T6, 2219-T87, 5456-H343 when welded had a decrease of approximately 50% in the endurance limit over that found for the parent metal at all temperatures. The 5456-H343 had the highest fatigue/tensile strength ratio. In the titanium group, both Ti-5Al-2.5 Sn and Ti-6Al-4V were superior at cryogenic temperatures to beta alloy Ti-13V-11Cr-3Al. Ti-5Al-2.5 Sn had the highest fatigue/tensile strength ratio. The welded Ti-5Al-2.5 Sn and Ti-6Al-4V specimens had reduced endurance limits over parent material of approximately 50%. Titanium alloys were superior to the aluminum alloys on the basis of fatigue/ultimate strength. In most cases elongation increased at cryogenic temperatures for the aluminum alloys but decreased for the titanium alloys.

REVIEW: The paper gives a clear account of the test apparatus, facilities, and procedures used to test several aluminum and titanium alloys at cryogenic temperatures. It would be difficult to find a better organized and better presented paper. ##

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64X15697

Serial Number 2199
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The prevention of fretting fatigue in aluminium alloy structures

AUTHOR: J. E. Bowers (The British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1)

SOURCE: Research Report No. A.1471, The British Non-Ferrous Metals Research Association, Apr 64, 19p (AD-442 939)

PURPOSE: To report on tests for preventing fretting fatigue.

ABSTRACT: Several methods of preventing fretting fatigue have been evaluated from rotating bending tests on flat tapered D.T.D. 683 high strength aluminum specimens on which fretting pads were applied at a predetermined contact load. The materials evaluated were inserted between the fretting pads and test specimen, and the results obtained were compared to the fatigue life of specimens tested without fretting pads. The materials evaluated included greases loaded with organic dyes and molybdenum disulphide; resin bonded surface coatings containing graphite, molybdenum disulphide, or PTFE; plastic or metal inserts including metal spraying of one of the contact surfaces; and surface treatments such as shot peening.

The results have shown that some resin bonded surface coatings are effective. The use of plastic inserts can also be effective with certain precautions. Shot peening, alumina blasting, and metal spraying used separately or in combination were better than nothing but not as good as resin bonded coatings. Greases were effective until they were squeezed out of the contact area.

Environmental conditions, design irregularities, and ease of application favor the use of methods such as shot peening, alumina blasting, and metal spraying. Tests made on joints using the latter methods resulted in a shifting of the failure to the holes because insufficient load was transferred across the joint by friction. Higher endurance limits may be obtained, if, along with methods to eliminate fatigue, the joint is designed to transfer the joint load by friction instead of through the bolts. Stress relieving at areas where fretting can occur is also beneficial and methods to accomplish this are described.

REVIEW: The paper illustrates several useful methods for reducing fretting fatigue and describes their limitations. It is clearly written and easily understood. Sufficient information is given on the procedures to make the paper of great value to anyone planning such investigations. ##

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65X19371
AD-467816

Serial Number 2200 -1
ASQC Codes 813;815;831;
845;871;872

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Weapon System Effectiveness Industry Advisory Committee (WSEIAC) Final Reports of the following Task Groups (in 10 volumes):

65X18175 - I: Requirements Methodology

① 65X19173 ② ③ 66X81244 II: Prediction-Measurement (Summary, Conclusions and Recommendations); (Concepts, Task Analysis, Principles of Model Construction); (Technical Supplement)

III: Data Collection & Management Reports

① 65X16000 ② 66X11379 IV: Cost-Effectiveness Optimization (Summary, Conclusions and Recommendations); (Tasks and Analysis Methodology); (Technical Supplement)

V: Management Systems (System Effectiveness, Assurance Summary, Policy Issues, Recommendations); (Elements of Effectiveness Assurance Management) ② 66X10134

AUTHORS: (A 64-member committee)

SOURCE: AFSC-TR-65-1 through 5 (in 10 volumes), Jan 65, System Effectiveness Division, System Policy Directorate, Headquarters, Air Force Systems Command, Andrews Air Force Base, Maryland (AFSC-~~TR-65-1:~~ ~~AD-458 453~~/AD-610 205; AFSC-TR-65-2 Vol. I: ~~AD-458 454~~/AD-610 204, Vol. II: AD-458 455/AD-610 203, Vol. III: ~~AD-458 456~~/AD-610 202; AFSC-TR-65-3: AD-458 585; AFSC-TR-65-4 Vol. I: ~~AD-458 595, Vol. II:~~ ~~AD-462 398~~, Vol. III: AD-458 586; AFSC-TR-65-5 Vol. I: AD-461 171, Vol. II: ~~AD-461 172~~)

AFSC-TR-65-1 - 65X18175
AFSC-TR-65-2 - 65X18173
AFSC-TR-65-4 - 65X16000
4 vol 2 66X11379
AFSC-R-TR-65-5 vol 2 - 66X10134
AFSC-TR-65-2 Vol 3 - 66X81244

PURPOSE: To present the results of an extensive study of the tasks involved in system effectiveness/cost effectiveness prediction and augmentation; to provide guidance on the technical and managerial aspects of the fundamental problems associated with achieving system effectiveness.

ABSTRACT: Task Group I reviewed present procedures being used to establish system effectiveness requirements and recommended a method for arriving at requirements that are mission-responsive. Definitions of system effectiveness and related terms are presented. Attention is directed to the preparation of SpecificOperational Requirements (SOR), a critical link between the conceptual and acquisition phases of a system. A major contribution toward achieving system effectiveness can be made by providing quantitative effectiveness in the SOR. Considerable confusion exists within industry and the military concerning the meaning of effectiveness and associated concepts. A proposed Air Force Manual for guiding the preparation of SOR including system effectiveness, and a proposed Air Force Regulation to formalize a program of effectiveness evaluation and prediction for the system life cycle are included as Appendices. Additional conclusions and recommendations are submitted relative to effectiveness requirements that constitute necessary steps in development of an Air Force wide effectiveness management program.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

Task Group II reviewed existing documents and recommended uniform methods and procedures to be applied in predicting and measuring system effectiveness during all phases of a weapon system program. Volume I of their Final Report contains summaries of the analytical concepts, examples, conclusions, and recommendations. A major recommendation is that effectiveness evaluation and analysis techniques be validated on systems in the early operational phase, and modified in accordance with the results. Other recommendations are that a data information center be established, and that studies be implemented on related questions pertaining to demonstration procedures, statistical confidence, incentive fee implications, and parameter estimation techniques. Volume II is a detailed exposition, by example, of the recommended mathematical framework in which it is proposed that system effectiveness be computed or measured. The adopted framework for system effectiveness includes an availability (readiness) vector, a dependability (reliability) matrix, and a capability (performance) matrix. The concepts, mathematical models, and tasks required to evaluate effectiveness are presented. An example is presented which uses these techniques; it includes computer flow diagrams for the application of Monte Carlo simulation methods. Volume III presents detailed analyses of four Air Force systems: airborne avionics, ICBM squadron, radar surveillance, and spacecraft. The intent of the examples is to provide detailed guidance in utilizing the proposed mathematical framework. They illustrate a variety of systems at different phases of development and levels of detail. Volumes II and III, addressed to project level personnel, provide a working knowledge of the proposed mathematical methods.

Task Group III reviewed the format and engineering data content of existing system effectiveness reports and recommended uniform procedures for periodically reporting weapon system status to assist all levels of management in arriving at program decisions. Three major study areas which evolved are: (1) raw data acquisition, (2) data information center, and (3) management reports. These studies resulted in the conclusion that cost, schedule, and technical performance factors are not being reflected in a manner adequate to provide comprehensive management visibility. It is recommended that The Air Force should establish a System Effectiveness Information Center (SEIC) to provide comprehensive and objective system effectiveness intelligence. SEIC would be a service organization. Also, each System Program Office should establish an information sub-system organizational capability comparable to other existing support-type subsystems. Data elements emphasized in this report are those for reliability and maintainability, while cost and capability parameters are not considered in detail. The appendices contain samples of reporting forms, a survey of computer systems for information retrieval, and examples of proposed data presentation formats.

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Task Group IV developed a basic set of instructions and procedures for conducting an analysis for system optimization considering effectiveness, time schedules, and funding. Results are presented in three volumes: (1) a summary, (II) procedural and analytical techniques, and (III) examples illustrating some of the cost-effectiveness methodology. Cost-effectiveness as a discipline is still in its infancy, and no single method for performing a cost-effectiveness study is currently possible or desirable. However, some standardization on a framework for these studies is appropriate. The Air Force should introduce in an evolutionary manner the cost-effectiveness evaluation approach on a cradle-to-grave basis. Additional recommendations pertain to such activities as personnel indoctrination, guideline development, methodology research, and data development.

Task Group V reviewed current policies and procedures of other Air Force Commands and developed a framework for standardizing management visibility procedures throughout all commands. Results are presented in two volumes: (I) the concept of a System Effectiveness Assurance Management System (SEAMS), and (II) a compilation of studies, reports, and interviews which document the current status of system effectiveness management. Implementation of a SEAMS requires participation and action by practically all Air Force Commands. Recommendations developed by this group touch on such topics as training, research, facilities, specifications, data, communications, audits, and evaluation. An overriding recommendation is that a position of Director of System Effectiveness Assurance be established at USAF Headquarters, with duties covering assurance activity, i.e. reliability, value, safety, and quality. (Authors in part)

REVIEW: Implementation of even a part of the recommendations of this committee should result in an increase of early consideration of the many characteristics of system effectiveness. The committee membership is well qualified, being comprised of a multi-disciplinary group of experienced persons.

The reports present the interface of reliability and maintainability with many other system considerations. Details in the various reports dwell primarily on topics of reliability and maintainability; a larger proportion of this detailed material could have been devoted to the means by which the established areas of schedules, costs, and performance are to properly intertwine with reliability and maintainability. This material will be of primary interest to systems analysts and management persons. Other workers in reliability will want to have some familiarity with the WSEIAC report, as it will be a milestone for systems orientation just as the AGREE report is for electronic equipment and the Darnell report for electronic parts.

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Volumes II and III of both Tasks Groups II and IV contain most of the detailed quantitative material and mathematical modeling; the remaining volumes are largely discussion. A Chairman's Summary Report will also be issued.

An excellent expository description of WSEIAC: its historical background, its products, the problem areas it identified, and its principal recommendations is found in [1]. System effectiveness and system cost-effectiveness are defined and discussed, both from a mathematical viewpoint, and in terms of their impact on management practices. An over-all task analysis is presented illustrating the sequence of steps that must be accomplished in the repetitive cycle of system effectiveness/cost effectiveness prediction and augmentation. This article, authored by one of the committee members, will be useful to those who want a brief, clearly-presented picture of WSEIAC accomplishments; it will also serve as background material for those whose ultimate objective is to study the specifics of the individual Task Group reports. More detail will be found in [2] from which [1] was excerpted. The longer paper includes a detailed activity network and explanation of the steps in a system effectiveness/cost effectiveness prediction/evaluation/augmentation cycle.

REFERENCES: [1] WSEIAC: A new standard for effectiveness evaluation, by Alfred J. Monroe, ARINC Research Corporation Newsletter, vol. 3, Jul 65, p. 1-8 (ARINC Research Corporation, 1700 K Street, N. W., Washington, D. C. 20006)

[2] Achievements of Weapons System Effectiveness Industry Advisory Committee (WSEIAC), by A. J. Monroe, 28p, in Proceedings Sixth Annual New York Conference on Electronic Reliability, May 65 (Copies available from the author: A. J. Monroe, Thompson Ramo Wooldridge, Inc., One Space Park, Redondo Beach, Calif.) ##

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Serial Number 2201
ASQC Code 873

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An aid to efficient maintenance

AUTHOR: W. S. Mortley (The Marconi Company Limited, Research Division, Radar Special Systems Section, Great Baddow, Essex, England)

SOURCE: Microelectronics and Reliability, vol. 3, p. 1-4, Jun 64 (Pergamon Press Limited, Headington Hill Hall, Oxford, England and 122 East 55th Street, New York 22, N.Y.)

PURPOSE: To describe an optical display for faults in large systems.

ABSTRACT: In extensive electronic systems, reliability of operation is difficult to attain by diagnostic methods of fault finding, because the greater probability of a component fault in large equipment leads to an increase in shut-down time. Operational time can be increased enormously if proper test devices are built into the equipment and continuously centrally monitored, to enable faulty units to be found quickly and replaced. This is also the case where redundant circuits are used, so that loss of redundancy due to a fault may be made good as soon as possible. Location of faults is greatly facilitated if all the equipment, including the fault indicator display, is decimalized in arrangement. It is essential that equipment should be designed for such monitoring from the beginning, as it is costly and inefficient to do otherwise. A broad approach to the problem is described, mainly in relation to low-power equipment, but also applicable to high-power apparatus.

The monitor which is described is capable of giving clear indications of conditions at more than 10,000 test points in 1/50 sec. An electro-mechanical system running at fifty selections/sec would take 3-1/3 min, which is far too long.

It must be accepted that adequate testing and monitoring may double the cost of equipment. Redundancy techniques, etc., may treble it, or more, bringing the cost up to perhaps six or seven times. Nevertheless, where complex equipment is essential (as in airport control, for example), all these cost multiplications must be incurred if reliability is to be achieved. (Author in part)

REVIEW: This article gives a general picture of the display mechanism and of the means for transmitting fault signals to the monitor. It does not discuss the transducers which transform faults into the electrical signals nor factors which must be traded-off in getting the optimum system. If the system described here can be easily fitted in and if the system itself will be quite reliable it may well be a distinct help to prompt repair of faults. The author states that the display equipment now incorporates a considerable degree of self-monitoring. ##

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Serial Number 2202
ASQC Code 838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A comparison of duplicate and triplicate redundancy schemes for binary logical networks

AUTHOR: J. C. Cluley (University of Birmingham, Electrical Engineering Department, Birmingham 15, England)

SOURCE: Microelectronics and Reliability, vol. 3, p. 51-59, Jun 64 (Pergamon Press Limited, Headington Hill Hall, Oxford, England and 122 East 55th Street, New York 22, N. Y.)

PURPOSE: To compare two kinds of redundancy for logic circuits.

ABSTRACT: Duplicate and triplicate redundancy schemes are compared with regard to the design, maintenance and testing problems they involve, and their possible improvement in reliability compared with a non-redundant system. More detailed consideration is given to a diode-transistor logical unit suitable for use in a high-speed digital computer.

The duplicate and triplicate redundancy schemes proposed for a basic logical unit have the same order of reliability, so that a choice between them must be made on other grounds, such as current gain, design restrictions, cost and power consumption. On balance, the triplicate scheme appears preferable, the advantage of the high gain and the use of standard logical units being generally more important than the disadvantages.

Although the total number of components required for a large triply-redundant computer may approach the formidable figure of 10^6, the future availability of integrated miniature logical circuits incorporating redundant elements, and possibly majority voting systems, should simplify the construction of redundant computers considerably. (Author in part)

REVIEW: This is a rather limited comparison of the two schemes. Even within the limitations the picture (or model) that is assumed for failure is not complete. The failures to ZERO and ONE are not equivalent, as discussed in the paper covered by RATR 1268. The comparison is done on the basis of a specific circuit which uses discrete components. Only in the conclusions are mentioned the mitigating influences of integrated circuitry. The assumption of statistical independence is made throughout. For very low levels of failure probability, this is not a good assumption. (The word "theoretically" is used to refer to the results of a very simple-minded analysis, not to those of a complete investigation.) The discussion, within these limitations, does provide insight into many redundancy problems. ##

Serial Number 2203
ASQC Code 820

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Letter to the Editor

AUTHOR: Drayton S. Palmer (The Marconi Company Limited, Research Division, Mathematics and Systems Analysis Laboratory, Great Baddow, Essex, England)

SOURCE: Microelectronics and Reliability, vol. 3, p. 77-79, Jun 64 (Pergamon Press Limited, Headington Hill Hall, Oxford, England and 122 East 55th Street, New York 22, N. Y.)

PURPOSE: To draw attention to certain errors in the AGREE report [1].

ABSTRACT: This paper discusses certain errors found in the values in Tables 6a and 6b on page 187 in [1]. In Table 6a an incorrect method was used to obtain the tabulated values when an exact procedure is available. An alternative table is suggested; however, it is pointed out that there are other ways in which the results might be presented. In Table 6b the values are obtained using the correct distribution. The meaning to be attached to the values must be considered carefully as they are not the usual 90% confidence levels. Additional errors are indicated.

REFERENCE: [1] <u>Reliability of Military Electronic Equipment</u>, Advisory Group on Reliability of Electronic Equipment (AGREE), Office of the Assistant Secretary of Defense (Research and Engineering), 4 Jun 57, U. S. Government Printing Office, Washington, D. C.

REVIEW: The author has made a very useful contribution in pointing out these errors. Their seriousness in practice depends upon the extent to which the specific tables and interpretations are used. In any case, one should not make use of the tabulated results unless he has a clear understanding of the assumptions and interpretations associated with them. ##

Serial Number 2204
ASQC Code 838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Redundancy techniques for use in an air traffic control computer

AUTHOR: D. J. Creasey (University of Birmingham, Electronic and Electrical Engineering Department, Birmingham 15, England)

SOURCE: Microelectronics and Reliability, vol. 3, p.175-192, Nov 64 (Pergamon Press Limited, Headington Hill Hall, Oxford, England and 122 East 55th Street, New York 22, N. Y.)

PURPOSE: To review the basic element redundancy techniques and error correcting codes.

ABSTRACT: In data handling systems, such as a computer used for air traffic control, component failures which cause unscheduled delays cannot be tolerated. In such systems maintenance is an integral part of reliability. Redundancy is one method which can be used to improve the system reliability. Circuit redundancy and information redundancy are used; these techniques and their application in an air traffic control computer are discussed.

Active circuit redundancy, passive checked circuit redundancy and coding all require additional electronic equipment. This equipment must not degrade the overall system reliability. For example, the length and error correcting capabilities of any particular code are limited by the reliability of the encoding and decoding equipments. Similarly the amount of active redundancy which can be applied is limited by the reliability of the switching arrays. Although "theoretically" maximum benefit results when component redundancy is used, still greater benefit results by combining redundancy techniques at all levels, and in all forms. The basis of applying redundancy should be to provide a simple basic system built from a few simple units designed to operate within agreed limits and under specified environmental conditions, so that the mean time between system failures is maximized. Redundancy techniques should then be applied, but the system must be kept reasonably simple and easy to maintain, so that the mean time to repair a fault is minimized. The system availability will then be a maximum. (Author in part)

REVIEW: This is a survey paper and summarizes some of the theory on element redundancy and error correcting codes. Statistical independence is implicitly assumed throughout the element redundancy discussion. There are some minor discrepancies but they do not detract from the overall presentation. The use of the term "theoretical" to imply the results of all theory is unfortunate, but not uncommon. What is meant in this paper, as usual, are the implications of a very simple-minded (even moronic) set of assumptions (or model). The optimization techniques mentioned are rather limited and do not include all the constraints. (Not all the results were checked.) ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The effect of circuit and component redundancy on the reliability of cryotron circuits

AUTHORS: Maureen Longden, L. J. Page and R. A. Scantlebury (National Physical Laboratory, Autonomics Division, Teddington, Middlesex, England)

SOURCE: Microelectronics and Reliability, vol. 3, p.253-262, Dec 64 (Pergamon Press Limited, Headington Hill Hall, Oxford, England and 122 East 55th Street, New York 22, N. Y.)

PURPOSE: To consider two types of redundancy for improving the reliability of a logic device.

ABSTRACT: This paper is a sequel to the paper entitled "Circuit Redundancy as an Aid to Making Functioning Cryotron Circuits" (Microelectronics and Reliability, vol. 3, p. 239-251, Dec 64), and considers the same types of redundancy, namely triplicated majority logic and hammock redundancy, as a means of improving the reliability of certain configurations of cryotron or other integrated devices.

Triplicated majority logic, although it reduces the chances of failure during the early operating life, does not increase the mean time between failures of the configurations considered.

Cryotrons lend themselves to the hammock configuration of redundant organization although the kinds of fault against which this guards may not be those most frequently found in cryotrons. However, for those types of fault with which it will deal, hammock redundancy would yield great improvement in reliability and extension in the mean time between failures. (Authors)

REVIEW: Even though the authors correctly assess the limited value of MTBF they do continue to use it in the analysis of redundant circuits. Mean failure rate over a limited time is a much better criterion for goodness if there can be repair. There appears to be a problem connected with the application of the analysis in that it may not be known whether all the cryotrons on a particular substrate are working at time zero or it may be very difficult to get a unit with all working. Thus the full benefits of redundancy may not be available. The assumption of statistical independence of failures is implicitly made. The fact that the devices are cryotrons is not brought into the algebraic analysis, although presumably the examples use numbers peculiar to these devices. The analysis itself is of the standard form for switching devices.##

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9/65 65A21100 Serial Number 2206
ASQC Code 850

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The cost of establishing reliability

AUTHOR: J. Yarnell (Hawker Siddeley Dynamics Ltd., Hatfield, Hertfordshire, England)

SOURCE: Microelectronics and Reliability, vol. 3, p. 303-305, Dec 64 (Pergamon Press Limited, Headington Hill Hall, Oxford, England and 122 East 55th Street, New York 22, N. Y.)

PURPOSE: To analyze the problems in proving an exponential failure rate.

ABSTRACT: It is becoming fairly general practice to predict the expected reliability of complex systems, using the concept of random failures characterized by a mean failure rate. Contractual and other penalties may result from failure to demonstrate at some agreed confidence level that the failure rate is expected to be below an agreed limit. On the other hand it may be quite costly to provide the equipment and to run the system for a sufficiently long time to demonstrate reliability.

This note shows that, assuming that the distribution of failures in time is random (Poisson), a quick demonstration of reliability can be expected only if the system is a good deal better than is demanded, and gives figures which help in planning the demonstration. (Author)

REVIEW: This is a well-known, well-analyzed problem. The mathematics in this paper was not checked in detail. The philosophic problem arises from the fact that prior knowledge is assumed to be zero in the statistical tests. If this is in fact true, then of course it makes no sense to talk about how much better the true MTBF must be--by hypothesis we have absolutely no knowledge of it. The trick is to find out how to use the prior knowledge that every manufacturer really does have about his product to make the test more efficient and to convince the buyer that this revised analysis of the data is also better for him. ##

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Serial Number 2207
ASQC Code 090

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Abstracts on microelectronics and reliability

AUTHOR: --

SOURCE: Microelectronics and Reliability, vol. 3, p.65-76, Jun 64; p. 139-149, Sep 64; p. 195-205, Nov 64; p. 307-320, Dec 64 (Pergamon Press Limited, Headington Hill Hall, Oxford, England and 122 East 55th Street, New York 22, N. Y.)

These are listings, including titles, authors, source identifications, and short abstracts, of papers grouped under the following headings:

- Reliability--General
- Reliability of Components, Tubes, and Transistors
- Circuit and Systems Reliability, Redundancy
- Maintenance
- Microelectronics--General
- Semiconductor Integrated Circuits
- Thin Film Integrated Circuits
- Electron Beam Technology
- Miscellaneous.

The sources are largely American publications. Some of the entries are as much as two years old. Most of the items pertinent to reliability have been covered by RATR. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An investigation of the rotating-beam test for low-cycle fatigue crack propagation studies

AUTHORS: E. A. Lange, T. W. Crooker, and R. E. Morey (U. S. Naval Research Laboratory, Metallurgy Division, Strength of Metals Branch, Washington, D. C.)

SOURCE: Naval Research Laboratory Report 6056, 17 Mar 64, 15p (AD-435 560) (A paper based on this report is found in Materials Research & Standards, vol. 5, p.352-358, Jul 65)

PURPOSE: To explore the use of a rotating-beam test for low-cycle fatigue propagation studies.

ABSTRACT: The use of a standard rotating beam machine is described for investigating the low-cycle fatigue (less than 10^5 cycle) behavior of HY-80 steel specimens heat-treated to three specific strength levels. One group of steel specimens is made from as-received steel (mill temper conditions); the two other specimen groups are both heat-treated for 1 hour at 1650°F, then water quenched, and tempered at either 400°F or 600°F for one hour. Low-cycle fatigue generally involves plastic strain which makes analysis difficult. Deeply notched specimens were used to localize plastic deformation and to provide a symmetry of crack movement through the specimen. Specimens were loaded to an initial nominal stress of 50 ksi, and the change in beam deflection due to crack propagation was recorded at regular intervals. At various beam deflections, some specimens were removed and tensile tested to obtain notch tensile strength data plus data to establish a calibration curve of crack depth vs. beam deflection. The following relationships were obtained and graphically illustrated for each group listed:

(a) Crack depth vs. beam deflection,
(b) Beam deflection vs. number of cycles,
(c) Crack growth rate vs. crack depth.

The results show a significant difference in the resistance to both crack initiation and crack propagation for the three groups under investigation. The mill temper steel in all cases had the lowest crack growth rate. The highest crack growth rate was found for the 400°F temper. Crack initiation, however, occurred at an earlier stage with the 600°F temper steel than with the 400°F temper steel. After a small initial period, crack growth rate was found to be in proportion to crack depth until stresses were reached that approached the notch tensile strength of the material.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

A size effect was found in mill temper specimens made in two sizes: 3/4 in. and 1-1/8 in. O.D. The latter suggests that comparisons must be made using the same size specimens. Notch tensile data are more realistic when a fatigue crack is used as the notch. Such data are used to show that a relationship exists between the ratio (crack rate)/(crack depth) and either Charpy V energy tests or the ratio (notch tensile strength)/(yield strength).

In general, as tempering temperature is reduced, low-cycle fatigue performance is also reduced.

REVIEW: The paper describes what seem to be ideal methods for establishing an index for the sensitivity of various materials to crack initiation and propagation. The paper's greatest value is in showing that a rotating beam fatigue test can be used for low-cycle fatigue investigations. ##

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64N23601

Serial Number 2209 -1
ASQC Codes 711;712;770

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An experimental investigation of the fatigue life and limit load characteristics of needle roller bearings under oscillating load conditions

AUTHORS: J. S. Tawresey and W. W. Shugarts, Jr. (Franklin Institute Laboratories, Philadelphia, Pa.)

SOURCE: Technical Documentary Report No. SEG-TDR-64-4, prepared by Franklin Institute Laboratories, Philadelphia, Pa. for Research and Technology Division, AFSC, Wright-Patterson Air Force Base, O. under Contract No. AF33(616)-3589, Mar 64, 139p (AD-437 467; NASA accession number N64-23601)

PURPOSE: To determine the factors influencing needle bearing life as encountered in helicopter rotor hinges.

ABSTRACT: The effect of cyclic oscillation on needle bearings was investigated under several conditions of radial load, frequency, angle of oscillation, and lubrication. It was hoped that an expression could be empirically derived which would describe the relationship between the above variables and bearing life. The needle bearing tested was representative of the type used in helicopter rotor hinges where cyclic oscillations are encountered in service. Failure was considered to occur with the presence of visually-observed flaking or spalling of the bearing surface. It was found that the cumulative percentage of failure was a linear function of life extending well beyond the B-10 or 10% failure point.

The conventional B-10 life rating (10% failure) is $L = (C/P)^3$ where L = life, P = radial load, and C = load factor for rotating service. In order to use this equation for oscillating needle bearing application, the value of C was calculated from the test data. Instead of being constant, C varied for the various tests, which indicates some interaction between variables. The value of the exponent in the equation was also found to vary for each test and ranged from 3.2 to 5.8.

Tests, made to determine the effect of prestressing for various numbers of cycles at loads higher than the test, show that prestress can be used to increase the load factor but also can cause a decrease under some conditions.

Fretting was not evident in any of the tests except in a case where a bearing was purposely run dry. The fact that fretting does occur occasionally in helicopter bearings is blamed on the lack of effective lubrication, which possibly could be caused by abrasive contaminants or moisture in the lubricant. Grease was generally found to be superior to oil from the standpoint

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of life.

The expected or mean life remains constant up to the median life; thus a bearing in service at a lower interval of life would be expected to have a life equal to that of a new bearing and thus should not be removed.

No expression relating bearing life to load, cycle, frequency of oscillation, or lubricant was found as a result of these tests.

REVIEW: This paper is primarily a presentation of laboratory data from which apparently the authors have failed to find an expression relating the independent variable to bearing life. The data might well be analyzed again using statistical techniques which establish the significance of interaction effects. The method used to establish failure does not appear to be sufficiently sensitive to prevent significant uncertainties in the data. It is not clear how the data in their present form can be used effectively in predicting bearing life for operating conditions where the independent variables may be subject to a wide range of values or for other bearing sizes. ##

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Serial Number 2210
ASQC Codes 782;833;837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Selecting cable tolerances

AUTHOR: Richard E. Shafer (Lockheed Missiles and Space Company, Van Nuys, Calif.; present address: Reliability Management Consultant, 14037 Oxnard Street, Van Nuys, Calif.)

SOURCE: Electronic Products, vol. 7, Jul 64, p. 28-29

PURPOSE: To explain how variations in cable voltage drop can arise.

ABSTRACT: The voltage drop in cables can be important in determining the voltage across the load. The reliability of many components is quite sensitive to applied voltage. Disregarding self-heating in cables, the variations in voltage drop due to variations in ambient temperature can be large, more so than those due to uncertainty in cable length. Tables are provided for making calculations. Particular attention should be paid to return leads and grounds.

REVIEW: The point that reliability of performance can be affected significantly by wiring and cable resistance variations is well taken. This is an important part of the infinite attention to detail that is required of designers. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: "To burn-in or not to burn-in" (A study of underlying mathematics of burn-in and some numerical investigations)

AUTHORS: W. T. Wells, Jay E. Queen (Pan American World Airways), John LaCapra, Charles J. Herbert, W. Dale Haygood, John E. Johnson, Livio F. Tami, and Don B. McClain (Radiation Incorporated)

SOURCE: Report of work done as part of the course Reliability Theory and Applications III at Brevard Engineering College, Melbourne, Fla., Dec 64 (copies available from John LaCapra, Radiation Incorporated, Melbourne, Fla.)

PURPOSE: To summarize the distribution theory pertinent to the burn-in problem and to present the results of some numerical investigations based on specific life density functions.

ABSTRACT: Burn-in is a technique which seeks to improve the reliability of components by operating them for a time under realistic conditions. If it is to be effective, the fraction that does not fail during burn-in should have a longer mean remaining life than the original items. The question of whether or not to use the technique can be answered only by an investigation of the life density function or the hazard function which pertains to the items. This report summarizes the pertinent distribution theory and presents the results of some numerical investigations based on the Weibull, mixed exponential, and log-normal density functions.

REVIEW: This study expands on work published by the first author (with G. S. Watson) in 1961 (see RATR 23). The chief element of expansion is the introduction of the ratio of reliability functions as opposed to relying on the ratio of mean lives. The reliability function is more meaningful than the mean life for all distributions other than the exponential. Thus the extension leads to a more meaningful criterion for the value of burn-in than did the original work, which considered only mean-life improvement. The results of numerical investigations in graphical and tabular form take up the bulk of the report. Some engineers may find the data interesting, but a good summary of findings accompanied by illustrative graphs and tables would have made for easier assimilation.

Section 7 of the report, which deals with estimation of the hazard function, presents a simple method which may be used by the practicing engineer who has data from only a few time points. While this method represents the best that can be done in many practical situations, the user should be aware that extrapolation based on a few data points can be quite risky. When available data permit, it is likely to be worthwhile to use one of the more sophisticated methods of estimating the hazard function (for which two references are cited in the report). ##

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Serial Number 2212-1
ASQC Code 871

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The relationship between reliability and the periodicity of scheduled maintenance

AUTHOR: F. S. Nowlan (United Air Lines, Maintenance Base, San Francisco International Airport, San Francisco, Calif.)

SOURCE: Presented at the 5th Annual West Coast Reliability Symposium, Los Angeles, Calif., Feb 64, 28p (*Proceedings available from Western Periodicals Company, 13000 Raymer Street, North Hollywood, California; Price $7.50)

PURPOSE: To report and discuss the results of a number of investigations of the relationship between reliability and the periodicity of scheduled overhaul for aircraft parts.

ABSTRACT: This paper is confined to the relationship between reliability and overhaul periodicity of the many appliances on the airplane; the structural hull is ignored. The use of teardown inspections to obtain information regarding predisposition towards failure is similar in principle to the use of airborne vibration monitoring equipment, spectrographic oil analysis, the analysis of functional performance parameters which are recorded on airborne maintenance monitoring equipment, etc. In all cases it is necessary to find what indications are representative of predisposition towards failure and to define maximum in-service levels of that particular indication.

The results of analyses to date indicate that:

1. Single simple items frequently show a deterioration in reliability with increasing age. Overhaul or total time limits, as appropriate, may be effective in controlling the reliability of such items.
2. There are a few critical modes of failure in certain appliances such as engines and these modes usually result from failure of single elements of the total assembly. The frequency of such modes of failure can be controlled by overhaul or total time limits.
3. Numerical analyses to establish time limits to control the frequency of critical failure modes must be based upon a measurable predisposition towards failure.
4. Overall measures of the reliability of complex components and systems, including overall measures of the reliability of the complete airplane, in most cases show either no deterioration with increasing age or a relatively slow rate of deterioration. Overhaul or total time limits are relatively ineffective in controlling the overall reliability of such items.
5. The relationship between reliability and time since overhaul can be determined in the absence of fixed overhaul time limits. This relationship will indicate what the magnitude of the ultimate

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time limits should be.

6. Techniques are being developed and tested which attempt during normal operation to measure the predisposition towards failure of the more important appliances on an airplane. If successful techniques of this nature are indeed developed, the role of periodic overhaul in maintenance programs will be greatly reduced.

No electronic equipment has ever yet showed a wearout characteristic. It is hoped that additional statistical analyses during future years will lead to the conclusion that overhaul at fixed times does not benefit this type of equipment. (Author in part)

REVIEW: This paper shows some of the problems involved in measuring the reliability while actually flying passengers. All of us have a rather personal interest in having passenger aircraft operate at maximum reliability. The aircraft companies are apparently doing a good job in this type of reliability improvement. None of the techniques are described intensively but a good overall picture is given. ##

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Serial Number 2213
ASQC Codes 831; 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The basic concepts of reliability measurement and prediction

AUTHOR: Everett L. Welker (General Electric Company, TEMPO, 735 State St., Santa Barbara, Calif. 93102)

SOURCE: Presented at the 5th Annual West Coast Reliability Symposium, Los Angeles, Calif., Feb 64, 45p (*see RATR 2212)

PURPOSE: To consider the fundamental concepts of reliability theory in order to show their unity.

ABSTRACT: Obviously prediction can be accomplished by many methods and perhaps many sets of basic concepts can be presented. However, the cleanest and most logical set of concepts is the set which minimizes subjectivity by relying on the engineering and operational aspects of the system under study to the maximum extent possible. The four concepts enunciated in this paper are believed to accomplish this objective because they assert the specification of the prediction probability problem in terms of the system and its uses and independently of the preferences of the analyst. In this view, the only real free choice is in the area of data collection and reduction. Thus we propose that it is possible to:

(1) define the system, or find out what we wish to study,

(2) perform an engineering analysis of properties of interest, or find out how the system works,

(3) quantify experience on like subunits in similar systems in probability language, or develop numbers appropriately descriptive of required basic facts, and

(4) perform a mathematical analysis which is tantamount to solving a probability problem stated in the previous concepts, especially in the engineering analysis.

The details of the mathematics and statistics used in the analysis are not part of the basic problem and it is not wise to classify reliability analysis methods by them. Other system parameters such as maintainability can be analyzed by following similar procedures. (Author in part)

REVIEW: This is a very good general paper. It does not discuss any method in detail, but rather gives the philosophy and approach which is useful in reliability. The adverse comments on such terms as inherent reliability are most appropriate. It is unusual to find a paper such as this which is useful to both practicing engineers and managers. Engineers, especially, should realize that papers such as this are valuable to them--otherwise they may be cutting trees in the wrong forest. ##

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9/65

Serial Number 2214
ASQC Codes 810;853

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Effective programs with management visibility reports

AUTHOR: Arnold A. Rothstein (Avco Corp., Research and Advanced Development Div., Reliability Dept., Wilmington, Mass.)

SOURCE: Presented at the 5th Annual West Coast Reliability Symposium, Los Angeles, Calif., Feb 64, 14p (*see RATR 2212)

PURPOSE: To demonstrate a simple reporting system for reliability progress.

ABSTRACT: The increased volume of paper generated in space and missile programs has created the problem of "not enough hours in the day to maintain an awareness of program status and problems." Various electronic data processing systems such as PERT, PERT-COST, and PRISM have been evolved to help our overloaded management. These techniques are being used successfully in many programs but all require separate training in the particular system, and specialized personnel to manipulate and interpret the method.

A simple non-EDP system was needed for reliability management which would provide clear, concise identification of program status and problem areas without requiring another lexicon of terms. The "Management Visibility Reports" described in this paper were developed to meet this need. These reports employ graphic charting, tabular arrangements and milestone schedules--all of which are familiar to management personnel. The format is designed to (1) minimize review time by the reader where no problem exists, (2) identify problem areas and their sources, and (3) indicate program status and effects of problem areas on schedules.

Experience gained with these reports on the Minuteman Re-entry Vehicle Program has prompted Air Force to consider this technique for application to all contractors. The description in this paper should be valuable to reliability and management personnel who are seeking a simple management reporting and control technique for their programs. (Author in part)

REVIEW: The merit of this program is difficult to assess from a paper. The paper does appear to be valuable and certainly is short and simple enough so that a manager would not mind reading it (this factor should not be underestimated). If there should be serious problems, the more complete and complex analyses will undoubtedly be of additional help. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Commercial reliability practices

AUTHOR: Richard B. Mulock (Lenkurt Electric Co., Inc., Subsidiary of General Telephone & Electronics Corp., San Carlos, Calif.)

SOURCE: Presented at the 5th Annual West Coast Reliability Symposium, Los Angeles, Calif., Feb 64, 17p (*see RATR 2212)

PURPOSE: To outline the reliability program at Lenkurt Electric Company.

ABSTRACT: This paper outlines the reliability assurance practices used to achieve equipment which will meet the needs of the telephone and allied industries who use large amounts of communications equipment. The total cost of all product assurance activities, including burden, overhead, space charges, salaries, material, capital expenditures (depreciation), and maintenance of all test equipment is less than 2% of the list price of goods and services sold. An analysis of our 45 Class system, which is vacuum tube and terminal construction, shows an average part failure rate of 0.05 failures per million part hours. An analysis of our low cost transistorized 81 Class equipment shows 0.045 failures per million part hours. (Author in part)

REVIEW: This is a very brief organizational and administrative article and will be of little value to specialists in the field because of its lack of depth. ##

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6

Serial Number 2216
ASQC Codes 831;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: RESCRIPT--A computer programming language for reliability

AUTHOR: Irvin R. Whiteman (Computer Concepts, Inc., Los Angeles, Calif.)

SOURCE: Presented at the 5th Annual West Coast Reliability Symposium, Los Angeles, Calif., Feb 64, 15p (*see RATR 2212)

PURPOSE: To describe a computer programming language for reliability.

ABSTRACT: This paper gives some general background information concerning the uses of computers in system reliability prediction. It is stated that some of the programming difficulties of treating complex systems of various configurations can be removed by the creation of a reliability-oriented language. One such language, referred to as RESCRIPT, is briefly described. One example is discussed indicating how the computer program would be implemented.

REVIEW: The author discusses an important problem area in computer programming for reliability predictions. One approach is given for removing the difficulty of providing computer programs subject to the limits of the time schedules of the design engineers. Other approaches to this problem are being considered; see, for example, [1].

RESCRIPT is a reliability-oriented language for treating various system configurations such as series, parallel, types of redundancy and switching in a failure rate prediction subject to given environments. Another important area in performance prediction is the one based on analytical or empirical models which relate the performance to the part characteristics, environments, and inputs.

REFERENCE: [1] Description of the computerized reliability analysis method (CRAM), by David E. Van Tijn, ARINC Research Monograph 11, 13 Nov 64, ARINC Research Corp., Washington, D. C. ##

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Serial Number 2217
ASQC Codes 222;774

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Testing of critical one-shot devices

AUTHOR: Michael M. Roth (Minnesota Mining & Manufacturing Co., Instrument Division, Hawthorne, Calif.)

SOURCE: Presented at the 5th Annual West Coast Reliability Symposium, Los Angeles, Calif., Feb 64, 17p (*see RATR 2212)

PURPOSE: To describe a constant risk sampling technique for the acceptance testing of critical one-shot devices.

ABSTRACT: Small lot sizes and high reliability requirements inherent in the space program have created a need for a systematic approach to selection of the number of critical one-shot devices to be functionally tested as a condition of acceptance. This paper defines the problem and provides a possible solution.

The selection of the number of units to be destructively tested as a condition of acceptance is dependent on the sampling technique and the sampling plan. This report demonstrates that constant risk sampling is the proper technique for use when high reliability requirements and small lot sizes are coupled with destructive attribute acceptance testing requirements. The necessary tables for the application of the techniques have been developed and are provided in the appendix.

A method of estimating reliability as a result of acceptance testing is suggested as a means of analytically selecting the appropriate risk and its associated sampling table (sampling plan) for a particular application; alternate methods predicated on a change to the normal testing cycle are introduced. (Author)

REVIEW: This paper will be of interest to those concerned with the selection of optimum sampling techniques for the destructive acceptance testing of critical one-shot devices. Its development arose from the lack of a suitable procedure in the Military Standard sampling techniques. The proposed procedure is clearly explained and the background for it is adequately referenced. The method of obtaining an a priori estimate of reliability for use in selecting the appropriate sampling table seems to have a rather ad hoc basis. However, it appears to be reasonable and should give satisfactory results when meaningful estimates of the three factors used to modify the AOQL are available. ##

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Serial Number 2218
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure analysis laboratories

AUTHOR: E. W. Kimball (Martin Company, Orlando, Fla.)

SOURCE: Presented at the 5th Annual West Coast Reliability Symposium, Los Angeles, Calif., Feb 64, 9p (* see RATR 2212)

PURPOSE: To present the need for failure analysis, even of "random" failures.

ABSTRACT: This paper discusses the need for special failure analysis laboratories to be used specifically for trouble shooting failed hardware during all phases of a program, not just R & D. Statistics obtained from a survey of contractors are cited to prove that organized procedures for analysis of failures are badly needed. A proposal is made for the military services to return all failed parts to contractors' failure analysis labs after weapon systems become operational. At present, hardware return is normally employed only during the R & D phase. Three case histories of laboratory investigations are presented as typical examples of the methods which are used to detect the cause of failures. The conclusion points out that increased emphasis on failure analysis would greatly improve reliability of aerospace systems. (Author)

REVIEW: Failure analysis, in economic proportions, is vital to high-reliability programs. This paper emphasizes that fact by examples. If one is already convinced, there is no need to read the paper. The papers covered by RATR 233 and 1145 by this author are on the same subject. ##

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Serial Number 2219
ASQC Code 832

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Zero defects--a management tool

AUTHOR: P. B. Crosby (Martin Company, Orlando, Fla.)

SOURCE: Presented at the 5th Annual West Coast Reliability Symposium, Los Angeles, Calif., Feb 64, 4p (* see RATR 2212)

PURPOSE: To describe the origins of the Zero Defects plan.

ABSTRACT: Most people have some aspects of their lives in which they expect no mistakes to be made--their pay checks, going to the right house each evening, etc. In other parts of their lives, however, they feel that mistakes are to be expected and thus they do not feel badly about them. The Zero-Defects program attempts to explain to each worker the importance of his being error-free and to extract from him a pledge to work for Zero Defects. This program has been a success at Martin-Orlando and has been copied in many places.

REVIEW: Good motivation of workers is a problem that has been with us for centuries (it was always "long ago" that everyone was a craftsman) and probably will be with us to some degree for centuries to come--if for no other reason than that we are rarely satisfied. The Zero Defects program appears to have succeeded in properly motivating a great number of workers. How permanent this will be without sustained and varied pressures is impossible to tell. Some people feel that any motivational program is doomed to fall back to mediocrity as soon as the pressure and initial enthusiasm are off. If this program continues to work, it will be an important milestone in reliability. It places emphasis on the "painstaking attention to detail," which is so vital to the production of reliable equipment. ##

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Serial Number 2220
ASQC Codes 813;815;850;
870;880

760;770

844

770;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

6

TITLE: Reliability responsiveness in technical proposals for electronic systems

but see 65N27741

AUTHOR: Milton V. Ratynski (U.S.A.F., Air Force Systems Command, Electronic Systems Division, L. G. Hanscom Field, Bedford, Mass.)

SOURCE: Presented at the 5th Annual West Coast Reliability Symposium, Los Angeles, Calif., Feb 64, 17p (*see RATR 2212)

Most of the information in this paper is found in the more recent paper by the same author covered by RATR 2021. The latter paper is virtually identical in content to the document AD-610 605.

6

TITLE: Flinching--a factor in estimating success probabilities

AUTHOR: David L. Field (Sandia Corporation, Albuquerque, N. M.)

SOURCE: Presented at the 5th Annual West Coast Reliability Symposium, Los Angeles, Calif., Feb 64, 7p (*see RATR 2212)

This paper was covered by RATR 1965.

65A23783

TITLE: Second thoughts on reliability

AUTHOR: G. A. Raymond (Sperry Rand Corporation, UNIVAC Div., St. Paul, Minn.)

SOURCE: IEEE Transactions on Reliability, vol. R-14, Mar 65 (published May 65), p. 66-72 (reprinted from IEEE Transactions on Aerospace, Apr 64) > 64A18116

This is a reprinting of the original paper referred to in RATR 1864. As such, it constitutes at least the fourth publication of the essentials of the original paper.

6

TITLE: Product failure: causes and prevention

AUTHOR: I. J. Fuchs (United States Testing Company, Inc., Hoboken, N. J.)

SOURCE: Mechanical Engineering, vol. 86, Feb 64, p. 36-39

This paper was covered by RATR 2080. ##

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65N30301

Serial Number 2221
ASQC Codes 330;813;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Component quality assurance programs for microminiature electronic components for Minuteman II

AUTHOR: Arnold J. Borofsky (Autonetics, A Division of North American Aviation, Inc., Anaheim, Calif.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 1-14 (*Edited by M. E. Goldberg and Joseph Vaccaro, RADC Series in Reliability; available from Defense Documentation Center or Clearinghouse for Federal Scientific and Technical Information)

PURPOSE: To discuss a component quality assurance program which provides an accelerated reliability growth of the electronic components used in the Minuteman II system.

ABSTRACT: The guidance and control system for Minuteman II utilizes a large number of new microminiature electronic components, including integrated circuits, micro geometry, and radial lead ceramic packages. Minuteman II has higher reliability goals which were to be achieved in less time than was used for Minuteman I. A failure rate estimation on each failure mode using all available information and estimated program costs to achieve failure rate goals were used on a cost-effective basis to select components for the assurance program. The program had two major areas: (1) a high-stress test program and (2) chemical, metallurgical, and physical analyses on the sub-component level. The test programs are designed to generate large numbers of catastrophic and drift failures. The physics of failure studies are aimed at determining the extent to which failures may be attributed to variability and imperfections in materials or processing which change with stress. Each of these efforts provides a body of failure-mode information which serves as a basis for early corrective action. The prime measure of program progress is the number of corrective actions; over 300 were implemented in less than two years. (Author in part)

REVIEW: This assurance program is for Minuteman II, and is not to be confused with its predecessor, the reliability improvement program for Minuteman I. This component program is the idealized type infrequently implemented in government contracting which involves the early expenditure of sufficient funds. An over-view of the program is presented in this paper, and not much detail. An interesting feature is that the numerical failure-rate estimates were made for individual failure modes for each component type. Hopefully the further experience and data resulting from this program will be published. ##

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10/65 65N 30302

Serial Number 2222
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Evaluation of r-f noise measurements for diode reliability improvement by the elimination of weak units

AUTHORS: L. Kirvida and C. Maronde (Honeywell Inc., Minneapolis, Minn.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 15-29, 7 refs. (*see RATR 2221)

PURPOSE: To explore the feasibility of using r-f noise as a tool to predict early failure.

ABSTRACT: A study of the noise characteristics of a general purpose silicon diode (type 1N645) was made to determine whether excessive r-f noise is correlated with high failure rates. The selection of the abnormally high noise diodes was made by monitoring the noise level across the diode as it was excited with an a-c voltage within the diode maximum ratings. Mechanical stress in the form of impacts within the rated value was applied simultaneously to aggravate structural imperfections. Noise measurements at 25 Mc were used for the recognition of weaknesses and early failure.

The forward and reverse characteristics were obtained for the diodes exhibiting high r-f noise. These were compared with the characteristics of diodes exhibiting normal r-f noise. In the forward direction, no difference was obtained; in the reverse biased condition, the average leakage current of all the noisy diodes was considerably higher than the average of the quiet group but the populations overlapped considerably. In addition it was noted that the r-f noise level of the diodes was almost inversely proportional to the avalanche breakdown voltage. The diodes were also tested for 1/f noise; 35% of the r-f noisy diodes also had high 1/f noise, whereas only 1.2% of the diodes with normal r-f noise had high 1/f noise. Dissection of a number of the r-f noisy diodes has shown some typical anomalies. Fractures in the silicon wafer as well as voids in the alloy bonding the wafer to the heat sink have been detected. (Authors in part)

REVIEW: This work is a valuable contribution both to screening and to physics of failure. It is most important to keep track of what was not proved as well as what was in studies of this kind.

The first author in a private communication has provided the following additional information. A life test was performed on a sample of 80 r-f noisy diodes and 80 quiet diodes to determine the correlation of r-f noise level with measured time to failure. After 1500 hours, 35% of the noisy diodes and 21% of the quiet diodes failed. The number of noisy diode failures after 1000 hours is 78% greater than the number of quiet diode failures, 65% greater after 2000 hours and 64% greater after 3000 hours. ##

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Serial Number 2223
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Application of power step stress techniques to transistor life predictions

AUTHORS: G. C. Sikora* and L. E. Miller (Bell Telephone Laboratories, Inc., Laureldale, Pa., *Now with the Western Electric Co., Laureldale, Pa.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 30-42, 11 refs. (*see RATR 2221)

PURPOSE: To explore the validity of the power step stress technique as a means of predicting life expectancy.

ABSTRACT: An n-p-n silicon mesa diffused transistor was used in these tests. Beginning at 600 mw, the power was raised in 50 mw steps every two hours until one half the devices in the lot had failed. Some tests were run at constant current, others at constant voltage. When estimating junction temperature from power dissipation, one must include both the emitter and collector power rather than just that of the collector. These tests have shown that:

1. The thermal resistance of a silicon mesa transistor is dependent on device operating conditions. This variation in thermal resistance results from nonuniform power density. When the proper thermal resistance is determined, maximum device junction temperature may be predicted over the entire range of possible operating conditions and is determined solely by total power.

2. Power life is limited by several different failure mechanisms which are stimulated in different operating regions. Although the different failure mechanisms are stimulated by different types of stress, the rate of device failure is still determined by device junction temperature. The gross discrepancy between temperature and power aging results often observed in silicon transistors is due to an incorrect determination of equivalent junction temperature. For devices similar to those discussed in this work, a single acceleration curve appears to predict adequately both temperature and power life expectancy. (Authors in part)

REVIEW: It is encouraging to find ways of bringing temperature aging and power aging results into agreement since the discrepancy has been noted by many people in the past. Of course it is not known whether this correction will put all the data in agreement, even those on well manufactured transistors. No model of cumulative damage is given in order to explain the straight line of median (step-stress) life vs reciprocal absolute temperature; the explanation is not immediately obvious, but it may be in the references. ##

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65 N30304

Serial Number 2224
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Emitter softening in diffused silicon transistors

AUTHORS: S. M. Henning and L. E. Miller (Bell Telephone Laboratories, Inc., Laureldale, Pa.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 43-60, 18 refs. (*see RATR 2221)

PURPOSE: To describe a mode of mesa transistor failure called emitter softening and to suggest its origin.

ABSTRACT: In silicon n-p-n double-diffused mesa transistors, emitter softening is a term which has been coined to describe a unique form of failure. It is characterized by an increase in the emitter leakage current which occurs during power aging. This specific type of failure does not usually occur during storage aging at high temperatures. The rate of failure of a device in this mode is proportional to the current density at which the device is operating. Thus the rate of failure is increased by localized areas of high current density. Detailed examination of the voltage-current characteristics of the emitter diode before and after failure show that the reverse characteristic of the diode changes from a predominantly avalanche mode of breakdown to one which exhibits the characteristics of field emission or tunneling. The presence of field emission suggests that the depletion layer is being modified to the extent that localized areas have very high electric field intensities.

An investigation of the cause of the field emission indicated that emitter softening is caused by the diffusion of residual metal impurities into the emitter. Such diffusion occurs most rapidly in areas of high temperature. Oxygen in the ambient of a device inhibits emitter softening. This is due to two effects of oxygen:

1. blocking paths of interstitial diffusion, and
2. oxidizing metal impurities.

Emitter softening can be prevented by eliminating contamination in etching, welding and other steps in fabrication. (Authors in part)

REVIEW: Diffusion of metallic impurities into semiconductor devices is something everyone "knows" is bad, although device failures seldom have been attributed to it. This worthwhile paper establishes certain circumstances under which this possibility has been found to be a reality. The fact that minimizing failures due to metallic diffusion was found to be inherent in the planar process could have been emphasized more by the authors. A photomicrograph (Fig. 8) showing evidence for the diffusion of gold across a silicon surface is particularly striking. ##

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Serial Number 2225
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Silicon surface leakage

AUTHOR: Donald J. Nicholson (Rome Air Development Center, Griffiss Air Force Base, New York)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 81-92 (*see RATR 2221)

PURPOSE: To study the dependence of the reverse current of a silicon junction upon the composition and pressure of the ambient.

ABSTRACT: The change in the room temperature reverse current of specially fabricated boron diffused p^+n silicon diodes was monitored as a function of time at various given pressures of different vapors and gases. The results of these measurements show two distinct modes of behavior: for uptake of gas by the surface both oxygen and water vapor cause an increasing exponential dependence of reverse leakage on time; for removal of absorbed species, the leakage shows an inverse power law dependence on time, with the exponent varying between 0.25 and 0.5. The value of this exponent is nearly linearly dependent on the initial value of leakage.

After conditioning at 90°C in a high vacuum the sensitivity to ambients is not observed. Furthermore, following such conditioning, even the room-temperature reverse current is no longer ambient-sensitive. After washing in methyl ethyl ketone the original sensitivity is restored. (Author in part)

REVIEW: No mention is made in this presentation of the actual number of junctions measured to obtain the values of reverse current plotted in Figs. 10-13. Some rather anomalous results are shown which are difficult to take too seriously without knowing the actual number of units that displayed these properties.

Some confusion exists due to the statement that junction depth, area, and surface concentration were varied. This statement immediately follows a reference to Fig. 7 which lists these values as constants. Many symbols throughout the paper are undefined.

The exponent representing the inverse power law dependence appears in Fig. 13 to be between 0.5 and 1.0 rather than between 0.25 and 0.5 as the author previously had indicated.

The introductory comments regarding the manufacturer's inability to control the ambient surrounding a device are interesting. Unfortunately no references are cited. Figs. 1-6 and the accompanying discussion are too brief to be of any value. ##

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Serial Number 2226
ASQC Codes 714;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The chemistry of failure of aluminum electrolytic capacitors

AUTHORS: Robert S. Alwitt and Reginald G. Hills (Sprague Electric Company, North Adams, Mass.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 93-107 (*see RATR 2221)

PURPOSE: To demonstrate the relationship between certain failure modes and particular electrode reactions for aluminum electrolytic capacitors.

ABSTRACT: Some of the most common failure modes of low voltage aluminum electrolytic capacitors are the result of slow chemical and electrochemical reactions on the electrode surfaces. These reactions are an inherent property of the Al/Al_2O_3/electrolyte system. Tested 5V and 10V capacitors (containing a glycol-borate electrolyte) that failed because of excessive changes in capacitance, dissipation factor, or leakage current usually showed (1) increase in anode foil capacitance accompanied by decreased ability to withstand voltage stress; (2) increase in cathode foil capacitance; and/or (3) production of gas, probably hydrogen. The same phenomena were observed by heating samples of commercial etched foil in a jar of glycol-borate electrolyte at 85°C. Accompanying the capacitance increase of anode foil was a weight loss due primarily to uniform dissolution of the aluminum oxide dielectric. Cathode foil treated in a similar fashion suffered a capacitance increase and a weight loss of metal substrate. No gas was evolved from the anode foil during this reaction but a gas, probably hydrogen, was collected over the cathode foil. Electron micrographs showed that some non-uniform attack of the anode and cathode foils took place at grain boundaries and at random sites within a grain.

Glycol-borate electrolyte is alkaline and contains some water. In this environment the dissolution of Al_2O_3 probably proceeded by reacting with hydroxyl ions. Where oxide was thinned to its equilibrium thickness further dissolution was accompanied by rapid production of new oxide; this is an electrochemical reaction. By changing the electrolyte or modifying the anodic oxide it is possible to reduce the probability of capacitor failure due to oxide dissolution. (Authors in part)

REVIEW: These tests and the report in this paper appear to be well done. It should be remembered that the authors have limited the paper to failure modes that presumably do not depend on impurities. There are failure modes which do depend on impurities in the aluminum and these can be important. ##

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65 N 30308

Serial Number 2227
ASQC Codes 720;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure mechanisms in reverse-biased oxide-passivated silicon diodes

AUTHORS: G. L. Schnable, E. S. Schlegel and R. S. Keen (Philco Corporation, Lansdale Div., Lansdale, Pa.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 108-121, 28 refs. (*see RATR 2221)

PURPOSE: To demonstrate how planar silicon diode failures, attributable to surface ion migration, may be reduced.

ABSTRACT: The electrical characteristics of planar silicon diodes and transistors degrade when they are aged with a reverse bias on the junction in a high temperature or gamma radiation ambient. The mechanism is believed to be ion migration in regions of high electric fields at the surface, which produces changes in surface potential of the silicon at the $Si\text{-}SiO_2$ interface. Experimental data show that the degradation rate is strongly dependent on the electric field strength. Unfortunately, there are a number of phenomena which increase the field strength above that for an ideal device. First, the impurity gradient at the junction is greater than that predicted by simple diffusion theory. Second, there can be a higher impurity density in the silicon adjacent to the oxide because of the rejection by the oxide of these impurities during the oxidation process. Third, the presence of the thermally grown oxide induces an accumulation layer in the n-type silicon at the surface. Fourth, the higher level of crystalline imperfection adjacent to the oxide may accumulate fast-diffusing impurities from the interior of the silicon.

Structural changes, such as the introduction of a narrow overlapping guard ring at the junction perimeter, or the use of a two-layer epitaxial structure, and process improvements, such as minimizing oxide pinhole density and gettering, lower the magnitude of the electric field in the surface depletion region and significantly decrease the failure rate of large area diodes. These modifications that improve the breakdown voltage capability are very closely related to those that reduce the failure rate due to ion migration phenomena. (Authors in part)

REVIEW: Straightforward topological designs seem capable of reducing the magnitude of the problem previously described by Metz (see RATR 1415) and others. While the solutions suggested in this paper do not appear to be particularly novel or ingenious, the improved performance thereby achieved is certainly noteworthy. The presentation is brief and clear. ##

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a 65N22242
b 65N30309

Serial Number 2228 -1
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure mechanisms at surfaces and interfaces

AUTHORS: Klaus K. Reinhartz, Virginia A. Russell, David L. Stockman, W. J. van Der Grinten and Warren L. Willis (General Electric Company, Electronics Laboratory, Syracuse, N. Y.)

SOURCE: (a) Technical Documentary Report No. RADC-TDR-64-454, prepared for Rome Air Development Center by the General Electric Company under USAF Contract No. AF 39(602)-3085, Feb 65, 102p, 33 refs. (AD-613 036; NASA accession number N65-22242)

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65N30309

(b) Physics of Failure in Electronics Volume 3, Apr 65, p. 122-141, 12 refs. (*see RATR 2221)

PURPOSE: To present a model for some dielectric-semiconductor interface degradation in CdS thin-film field-effect transistors.

ABSTRACT: The paper (second SOURCE) is a summary of most of the work in the report (first SOURCE).

Failure mechanisms at surfaces and interfaces in thin film structures have been studied in thin-film field-effect triodes. These triodes are very suitable for the study of failures at semiconductor-insulator interfaces as the electrical characteristics strongly depend on the state of this interface.

The thin film triodes have been subjected to humidity, to elevated temperature, and electrical "stress." During the "stress" tests the drift of the main parameters which depend on the material has been studied as a function of time and "stress." The main drift was in the threshold or pinch-off voltage, indicating that the surface potential of the semiconductor changed. The field-effect mobility and the gate capacitance were rather constant. The rate equation describing the change of the threshold voltage at elevated temperatures was explained by assuming a desorption process; it was shown that water contributes to this effect. A tentative model for the failure mechanisms under electrical "stress" is based on a correlation of the observed failure modes and the slow relaxation characteristics of the semiconductor conductance.

The experimental devices could be classified in two types which showed a distinctly different slow relaxation behavior. After a field of the proper direction was applied to the gate electrode of the triode, first, the conductivity of the semiconductor increased very rapidly. This initial increase of the conductivity was either followed by a partial decrease (negative relaxation = NR) or by a further increase (positive relaxation = PR). The time constants of these relaxation processes were similar in both types and about

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1 to 20 seconds. Tentatively, the PR phenomenon was linked to the field ionization of water molecules at the semiconductor-insulator surface. The difference in type NR and PR samples depended only on the treatment of the semiconductor surface before the insulator film is deposited.

Both types behaved differently in the electrical "stress" tests. NR samples showed a slow increase of the threshold voltage whereas the threshold voltage decreased in PR devices. (Authors in part)

REVIEW: Work in this field is difficult and progress is slow; the project described in this report is no exception. The title, of course, is much too general; the actual project dealt with a very specific interface. The conclusion that ion (molecule) migration causes surface potential changes is in accord with the results of most other investigations.

In a private communication the first author has made the following comment: "A main point of interest in these MOS systems is the location of the mobile charged impurities.... The work at IBM suggests that charge accumulation in the insulator layer is responsible, whereas according to the work at Clevite-Shockley Laboratory charge transfer at the insulator-air interface is important. We could demonstrate that the surface treatment of the semiconductor before the insulator deposition affects the failure mode of the thin film transistors drastically and from this observation we concluded that the change of the concentration of charged impurities at the semiconductor-insulator interface may represent an important failure mechanism, too."

The text in the report is not too well written; at best, some of the terminology is non-standard. The contribution of this report is in the experimental work, not in an advance in knowledge about interfaces. ##

10/65 65N30310 Serial Number 2229 -1
ASQC Codes 773;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Planar silicon device failure mechanism studies with the micro-analyzer electron probe

AUTHORS: C. C. Nealey and C. W. Laakso (Autonetics, A Division of North American Aviation, Inc.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 142-171, 18 refs. (*see RATR 2221)

PURPOSE: To describe the application of the electron microprobe to the investigation of silicon device failure.

ABSTRACT: The electron microprobe examination of silicon devices gives complementary information from back-scattered electron, specimen current, and X-ray patterns. The interpretation of these patterns is complex but can yield much information on the device structure. This is more accurately described as a nondisintegrating test than as a nondestructive test although, in some cases, it has been possible to anneal out the effects of the electron irradiation which occurs during examination.

REVIEW: A large amount of apparently useful and valuable experience in the application of the electron microprobe to silicon device examination is described in this paper. As in other accounts of these techniques (see RATR 1310 and 1459) the patterns are impressive in the detail shown and the information offered. For example, in one figure (Fig. 5) clear evidence is shown of chloride attack on an aluminum conducting pattern in a silicon integrated device. The optical pattern shows damage, the specimen current pattern shows discontinuities in the conducting path, the back-scattered electron pattern shows contamination, and the X-ray pattern clearly indicates the presence of chlorine.

With a wealth of information and some dramatic figures to draw on, it is regrettable that the preparation of this paper is weak. One might accept inconveniences such as the apparent use of "Q" as the symbol for current, the lack of references (no identification of "the equation of Archard" on p. 146), or the mis-numbering of figure references (Fig. 13 referred to on page 161 is supposed to be Fig. 16), were these not typical of the remainder of the paper. There is considerable difficulty in following the text. For example, on p. 148, in discussing the specimen current variations, the authors refer to some disturbing events when the electron hole current (?) was of opposite polarity or absent altogether. This is, at best, vague. Why, on p. 150, does the transistor have high capacitance ("W_c"!) at the collector compared to the other two leads (capacitance to what?) The figures and Table 1 do not have enough information for ready interpretation.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

This research which is, without doubt, making important contributions to the knowledge of silicon device failure mechanisms and to electron microprobe applications should be reported much more clearly (see RATR 1459 for a previous report from the same group). For those who are particularly interested in silicon device failure mechanisms, this is worth the effort to read. For those with a more casual interest, examine the figures but wait for a clearer description. ##

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Serial Number 2230 -1
ASQC Code 775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Evaluation of selected methods for detecting contaminants within semiconductors

AUTHORS: L. D. Clark, J. C. Burrus, and R. D. Clark (Texas Instruments, Incorporated)

SOURCE: Proceedings Institute of Environmental Sciences 1965 Annual Technical Meeting, Chicago, Ill., Apr 65, p. 65-71 (*Institute of Environmental Sciences, 34 S. Main Street, Mt. Prospect, Ill.)

PURPOSE: To present an evaluation of selected methods for identifying semiconductor devices containing particles which might prove detrimental to device operation.

ABSTRACT: Malfunctions in missiles and satellites using transistors can often be due to small conducting particles inadvertently encapsulated within the device. This paper is concerned with nondestructive testing methods to detect devices containing such particles.

The first test method described consists of a low amplitude constant frequency vibration, with simultaneous and continuous monitoring of appropriate electrical parameters of a semiconductor for indication of a short. This was found to be the most suitable means of detecting extraneous lead wires of varied lengths down to somewhat less than 0.1 inch. The appropriate parameter can either be monitored visually for an indication of shorting using an oscilloscope or can be monitored utilizing a triggering circuit activating a relay.

A second test method was designed to detect small, dense, spherical-type contaminants by monitoring for an acoustical indication of their presence. A special fixture was designed which would hold a semiconductor in contact with the surface of a piezoelectric accelerometer. The fixture-accelerometer-semiconductor combination was then subjected to a low amplitude fixed frequency vibration so that any loose particle within the device would randomly impinge against the device case, and in so doing excite the accelerometer. The small voltage thus generated was fed through a filter to an oscilloscope for visual observation. This method was found to be most suitable for detecting small, dense, spherical contaminants and was capable of detecting special lead pellets as small as 0.004 inches in diameter and 7 micrograms in mass.

The two test methods described above were incapable of detecting particles which were wedged in place at the time of inspection but might later become free to move within the device. To locate faults of this type, radiographic inspection was introduced. This proved to be a very acceptable technique. Results of an evaluation of these test methods are discussed. The monitored

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

vibration test method is not suitable for reliably detecting 100% of the particle types and has a lower size limit of detection which depends upon the geometry of the device under test. Increased severity of tests results in increased sensitivity of detection; both in more devices containing given-sized particles detected, and in detection of devices containing smaller particles. More contaminants were detected by radiographic means than by any other, both of the spherical particles and the elongated leads. This method was capable of resolving particles which were generally smaller than those detected by the other means. Thus, the lower limit of detection using this method is somewhat better than that for the monitored vibration test.

In the tests reported in the paper, seven devices were detected using monitored vibration which were not detected using X-ray. If this number were added to 74 devices detected using the radiographic technique, a total of 81 out of 117 defective devices were detected. It thus appears that the single test method most desirable from the standpoint of detecting particles within semiconductor devices is radiographic inspection. For maximum assurance of particle-free devices, however, the monitored vibration supplementing the radiographic inspection test provides 10% increase in detection capability. (Authors in part)

REVIEW: The nondestructive testing methods described in this paper were directed toward the solution of a special problem--a very important problem from the standpoint of users of semiconductor devices. In the tests reported, the "batting average" of radiographic inspection supplemented by monitored vibration is about 70%. The results are clearly presented and the paper is a worthwhile contribution to the literature on nondestructive testing techniques. ##

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Serial Number 2231
ASQC Codes 770;780;813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Upgrading unmanned spacecraft quality and reliability through environmental testing

AUTHORS: Kenneth R. Mercy and Albert R. Timmins (NASA/GSFC)

SOURCE: Proceedings Institute of Environmental Sciences 1965 Annual Technical Meeting, Chicago, Ill., Apr 65, p. 193-200 (*see RATR 2230)

PURPOSE: To present some laboratory and space results illustrating the implementation of the Goddard Space Flight Center philosophy of upgrading spacecraft reliability through environmental testing.

ABSTRACT: The variability in the design of unmanned spacecraft, and in the many people both domestic and foreign who participate, has been illustrated by Relay I, Ariel I, and Echo II projects. The difficult task of obtaining high reliability in each of these differing systems has been accomplished by following the Goddard Space Flight Center philosophy of upgrading through environmental testing. Locating and correcting deficiencies resulting from design qualification tests or flight model acceptance tests are major contributions in upgrading the quality and reliability of spacecraft. Laboratory and space results are presented and discussed.

Each of the projects, Relay I, Ariel I, and Echo II, is outlined, and the spacecraft are described briefly. The essentials of the corresponding environmental testing programs are indicated. Emphasis is placed on the variability in space program problems and requirements, and the part played by the test and evaluation program in achieving space performance objectives. (Authors in part)

REVIEW: This is a clearly-written paper which accomplishes its purpose quite well. Through the medium of typical examples of space project experiences, the authors have brought out the value and importance of environmental testing programs. More detail on various aspects of these programs will be found in four references cited in the paper. ##

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ASQC Codes 711;773;783

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Environmental testing in support of satellite design at the Royal Aircraft Establishment

AUTHORS: H. A. J. Prentice and J. Porter (Royal Aircraft Establishment, England)

SOURCE: Proceedings Institute of Environmental Sciences 1965 Annual Technical Meeting, Chicago, Ill., Apr 65, p. 633-643, 15 refs. (*see RATR 2230)

PURPOSE: To describe the environmental testing program and facilities used in satellite design at the Royal Aircraft Establishment.

ABSTRACT: The first British-built satellite designated U.K.3/S.53 is due to be put into orbit in 1966 by a Scout rocket. This application of space technology has made it necessary to define the environmental parameters which affect a satellite's performance. A test philosophy has been developed which is based on an integrated range of facilities. Test techniques are described for evaluating thermal control surface characteristics, for examining the effect of the space environment on materials, for thermal testing of components and, finally, for checking the reliability and thermal balance of a complete satellite in a space environment simulator. These tests are discussed against the background of the U.K. 3 satellite although they are applicable to other space programs.

The following elements of the space environment and their effects on satellite performance are briefly described: vacuum, corpuscular radiation, electromagnetic radiation, micrometeorites, and weightlessness. Reference is also made to the pre-launch and launch environments. The test program for U.K.3 begins with the evaluation of materials and components, passes through the design stage to the testing of equipment packages and satellite subassemblies and onto the testing of complete satellites in a thermal vacuum chamber and in a space environment simulator. The last technique relies on interpretation and extrapolation of results to finally assess the satellite's performance. The facilities for space environment simulation and evaluation of satellite materials at the Royal Aircraft Establishment are described and summarized in an appendix. (Authors in part)

REVIEW: This is a good compact discussion of the space simulation and evaluation techniques used at the Royal Aircraft Establishment. For those who desire more details, references are cited. As the authors have indicated, much of the knowledge gained to date is in terms of facilities required, their limitations, and how to make the best use of them. The technical results and experience gained will be of value in planning space simulation testing on other satellite projects. ##

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Serial Number 2233
ASQC Codes 720;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A study of the determination of manufacturing problems significantly affecting reliability of silicon planar devices

AUTHORS: M. W. Larkin and M. J. Geisler (Westinghouse Electric Corporation, R and D Center, Beulah Road, Pittsburgh 35, Pa.)

SOURCE: Final summary report prepared by Westinghouse Electric Corporation under Contract No. NAS8-11382 for the George C. Marshall Space Flight Center, NASA, Jul 64 to Dec 64, 57p, 77 refs. (NASA accession number N65-18249)

PURPOSE: To present a detailed analysis of materials and processing problems in the fabrication of silicon planar devices.

ABSTRACT: This report describes the planar process for silicon integrated circuits and power transistors, and catalogues the various problem areas characteristic of the current state-of-the art. The most severe are those associated with the assembly and encapsulation of completed chips. Other major problem areas are quality demonstration testing and reliability characterization.

REVIEW: The treatment of this timely topic is too general to be of much value to the reader who is already familiar with the manufacturing problems of planar silicon devices--he undoubtedly already knows what is written in this report. On the other hand, the reader who is not previously acquainted with the problems will find the treatment too superficial. The report appears rushed. Sentences such as: "All quality elements are complied with either by monitoring, or by direct responsibility of the specific effort," and "Table II shows the yield of a number of devices on slices going through all processes (etching, diffusion), however, no masks were used so that the masking capabilities of the resists only could be examined." would normally have been altered in review. On p. 26, aluminum is "almost always used (to form ohmic contacts and interconnections) because it adheres well to the silicon dioxide." On p. 28 one of the major disadvantages of the aluminum-gold bonding system is "the poor mechanical bond occurring when aluminum does not adhere well to the SiO_2 surface."

The conclusions, consisting of a listing in order of importance of the problems associated with the manufacturing of long-lived high-quality planar devices, are not particularly substantiated by the discussion. For example, that packaging and bonding should be identified as the most significant problems is not surprising, but the body of the report does not make this conclusion inevitable or even apparent. ##

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65 N19389

Serial Number 2234
ASQC Codes 412;822;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An exact asymptotically efficient confidence bound for reliability in the case of the Weibull distribution

AUTHORS: M. V. Johns, Jr. and G. J. Lieberman (Stanford University, Dept. of Statistics, Stanford, Calif.)

SOURCE: Technical Report No. 75, Department of Statistics, Stanford University, Stanford, Calif., supported by the Army, Navy, Air Force and NASA under Contract Nonr-225(53) (NR-042-002) with the Office of Naval Research, 18 Dec 64, 49p, 20 refs. (AD-609 259; NASA accession number N65-19389)

PURPOSE: To present a simple method for obtaining exact lower confidence bounds for reliabilities (tail probabilities) for items whose life times follow a Weibull distribution where both the "shape" and "scale" parameters are unknown.

ABSTRACT: This report presents a simple method for obtaining exact lower confidence bounds for reliabilities (tail probabilities) for items whose life times follow a Weibull distribution where both the "shape" and "scale" parameters are unknown. These confidence bounds are obtained both for the censored and non-censored cases and are asymptotically efficient. They are exact even for small sample sizes in that they attain the desired confidence level precisely. The case of an additional unknown "location" or "shift" parameter is also discussed in the large sample case. Tables are given of exact and asymptotic lower confidence bounds for the reliability for sample sizes of 10, 15, 20, 30, 50, and 100 for various censoring fractions. (Authors)

REVIEW: This is a mathematical paper which is a contribution to the literature on reliability estimation based on the Weibull distribution. Its particular importance lies in the fact that previously no satisfactory method has been given for computing lower confidence bounds for reliability which are exact for each sample size when both the shape and scale parameters are unknown, particularly in situations in which n items are tested simultaneously and independently and the test is terminated when the first r out of the n items have failed. The material is clearly presented and adequately referenced. An illustrative example is given.

The following erratum has been supplied by the authors. The statement beginning after the equation in line 8 on page 13 should read: "... the asymptotic methods detailed above may still be used if it is known a priori that σ is greater than 1/2 since $X_{(1)} = \min(X_1, X_2, \ldots X_n)$ is then a 'super-efficient' estimator of θ." ##

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65N18285

Serial Number 2235
ASQC Codes 412;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Approximate confidence limits for the reliability of series and parallel systems

AUTHOR: Albert Madansky (The RAND Corporation, Santa Monica, Calif.)

SOURCE: RAND Corporation Memorandum RM-2552-1-PR, prepared for USAF Project RAND, Contract No. AF 49(638)-700, Dec 64, 15p, 6 refs. (AD-609 429; NASA accession number N65-18285)

PURPOSE: To present a new technique for obtaining approximate confidence limits for the reliability of a series, parallel, or series-parallel system when only component-failure data is on hand.

ABSTRACT: Suppose a complex mechanism, e.g., a missile, is built up from a number of different types of components, where the reliability of each of the components has been estimated by means of separate tests on each of the components. This paper gives a method for combining such data to determine approximate confidence limits for the reliability of the complete mechanism. More precisely, a method of determining approximate confidence limits for the reliability of "series," "parallel," and "series-parallel" systems is given, based on observed failures of the individual components. It is assumed that the failures are independent, and that failures of a given component follow a binomial distribution with unknown parameter, the component reliability. The large-sample properties of the likelihood-ratio test are then used to construct the appropriate confidence limits for the system reliability. (Author)

REVIEW: This is a mathematical paper addressed to the solution of an important problem in reliability estimation. The material is compactly and clearly presented. The relationship of the procedure to other methods of obtaining confidence limits for the reliability of series and parallel systems is brought out, and pertinent references are cited. The principal advantage of this method is computational ease, and the approximation is quite good for "moderate" reliabilities (less than 0.8). One of the "exact" methods (referenced in the paper) should be used for cases involving extremely high reliabilities. ##

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65 X17937

Serial Number 2236
ASQC Code 821

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Theory of reliability for coherent structures

AUTHOR: Z. W. Birnbaum (University of Washington)

SOURCE: Technical Report No. 41, Laboratory of Statistical Research, Department of Mathematics, University of Washington, Seattle, Wash., supported by the Office of Naval Research, Contract N-onr-477(11), Apr 65, 15p (AD-462 482)

PURPOSE: To give an expository presentation, complete with proofs, of some aspects of a mathematical theory dealing with the relationship between the functioning and failure of single components and the performance of the entire system.

ABSTRACT: Assuming that each component of a system, as well as the entire system, can only either perform or fail, the dependence of the state of the system on the states of the components can be described by a binary function of binary variables $\Phi(X_1, X_2,\ldots,X_n)$, where $X_i = 0$ or 1 according to whether the i-th component fails or performs, $i = 1,2,\ldots,n$, and $\Phi = 0$ or 1 according to whether the system fails or performs. An important subclass of such functions are the coherent structure functions which satisfy the requirements: 1) Φ is non-decreasing in every variable, 2) $\Phi(0,0,\ldots,0) = 0$, $\Phi(1,1,\ldots,1) = 1$. For coherent structure functions results are obtained dealing with their representation in terms of minimal paths (or cuts), numbers of paths (or cuts) of different sizes, and other algebraic properties. If the states of the components $X_1, X_2,\ldots,X_n$ are independent random variables with given $\Pr\{X_i = 1\}$, then a study of the "system reliability" $\Pr\{\Phi(X_1, \ldots, X_n) = 1\}$, yields a number of interesting and practically applicable results. (Author)

REVIEW: This paper is a collection of theorems and proofs. Not all of the details were checked, but the work appears to be of high caliber. It will be of interest to the theorist concerned with mathematical modeling for systems to which the author's assumptions apply. In practice these could be quite limited. The results, after suitable interpretation, could possibly lead to useful design ideas. ##

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10/65 65N27974 Serial Number 2237
ASQC Codes 413;551;822

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Tests for monotone failure rate

AUTHORS: Frank Proschan (Boeing Scientific Research Laboratories) and Ronald Pyke (University of Washington)

SOURCE: Mathematical Note No. 400, Mathematics Research Laboratory, Boeing Scientific Research Laboratories, Mar 65, 44p, 18 refs.

PURPOSE: To propose and investigate a non-parametric test to determine whether a sample comes from a population having an increasing failure rate.

ABSTRACT: Physical considerations often lead one to expect that a distribution has increasing failure rate, and knowledge of increasing failure rate is mathematically useful in solving a variety of practical problems. In this paper, a non-parametric test to determine whether a sample comes from a population possessing an increasing failure rate is proposed and investigated. The test statistic is based only on the ordering of normalized spacings between the ordered observations. The distribution of the test statistic under the null hypothesis of constant failure rate is known. Suitably normalized, it is shown to be asymptotically normally distributed for a wide class of alternatives. In particular, under mild assumptions, when the underlying distribution has increasing failure rate, the test statistic is asymptotically normally distributed. The test is shown to be unbiased. The criterion of asymptotic relative efficiency is used to compare the test proposed with the likelihood ratio test for Weibull alternatives and with the likelihood ratio test for Gamma alternatives. (Authors)

REVIEW: This is a clearly-presented mathematical paper which will be of interest to the theorist rather than to the reliability engineer. The orientation of the work relative to other published material in this topic area is clearly set out, and adequate references are cited. ##

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Serial Number 2238
ASQC Codes 822;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Bounds for lattice distributions having monotone hazard rate with applications

AUTHOR: Gamanlal P. Shah (University of California, College of Engineering, Operations Research Center, Berkeley, Calif.)

SOURCE: Report ORC 65-2, Operations Research Center, University of California, Berkeley, Calif., partially supported by the Office of Naval Research under Contract Nonr-3656(18), Jun 65, 34p, 15 refs.

PURPOSE: To derive bounds on lattice distributions under the increasing (decreasing) failure rate assumptions.

ABSTRACT: A discrete distribution of a random variable X is called a lattice distribution if there exist real numbers a and $h > 0$ such that every possible value of X can be represented in the form $a + kh$, where k runs through integer values. We call h the span of the distribution. The geometric, binomial and Poisson distributions are important examples of lattice distributions.

Lattice distributions occur naturally in many applications. Fatigue failure data obtained under dynamic loading is commonly recorded in terms of the number of cycles to failure. For many structures subject to fatigue failure, a lattice increasing failure rate distribution would seem appropriate. Other examples include human mortality data where it is common to record time of death to the nearest year or the nearest month, and certain types of cancer mortality data for which a decreasing failure rate seems appropriate.

Using methods which have been employed for obtaining bounds on continuous failure distributions, bounds on lattice distributions are derived under the increasing (decreasing) failure rate assumptions. The discrete bounds are convenient in a number of applications such as life table analysis and reliability theory. (Author in part)

REVIEW: This paper is a contribution to theory related to certain types of problems occurring in reliability and related topics. Not all of the mathematical details were checked but the work appears to be of high caliber. Appropriate references are cited to place the work in perspective.

The type of reliability problem which the results of this study will solve is illustrated through application to the problem described in the paper covered by RATR 1049. For data following a distribution with a decreasing failure rate, an upper bound is found for the survival probability. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability analysis of non-electronic components using Weibull, gamma, and log normal distributions

AUTHOR: Dutton G. Stoy (Capt., USAF)

SOURCE: Thesis presented to the Faculty of the School of Engineering of the Air Force Institute of Technology, Air University in partial fulfillment of the requirements for the degree of Master of Science, Aug 64, 73p, 37 refs. (AD-610 774)

PURPOSE: To present the results of a literature search to discover as many examples as possible of the use of the Weibull, log normal, and gamma distributions in the reliability analysis of non-electronic components.

ABSTRACT: Reliability analysis using the Weibull, log normal, and gamma distributions for non-electronic components is complicated by non-standardization, small lot sizes, and the interaction between components. The Weibull distribution is useful in the failure analysis of structures, ball bearings, brittle beams, and spin gyros. The log normal distribution is used in the failure analysis of the aircraft structures and helicopter blades, while the gamma distribution is useful in failure analysis of aluminum strips. Data for a particular example may often be fitted to more than one of the distributions with equal success.

This paper presents the results of a literature search to determine what mechanical and electromechanical devices can be analyzed using the Weibull, log normal, and gamma distributions. These distributions are discussed in sufficient depth to allow the reader to relate them to the application given. In each case the discussion includes one or more methods for obtaining estimates of the parameters of the applicable distribution. For the Weibull and log normal distributions a graphical method is discussed. For the gamma distribution the maximum likelihood method is presented.

In presenting the applications actual failure data are used where it was possible to obtain such data. When it was not possible to obtain failure data a discussion of the particular application is given. Actual failure data are used in applying the Weibull distribution to ball bearings, brittle structures, and spin gyros; and the gamma distribution to aluminum coupons.

One must realize that in applying any distribution to a small sample size it is at best only an approximation to the parent population. To illustrate this the final part of the paper compares failure data, showing that they could have come from either the Weibull, log normal, or gamma distributions. (Author in part)

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

REVIEW: This is a commendable piece of work which accomplishes its purpose quite well. While no claim is made for the completeness of the literature search, it does seem to have been quite extensive. It will be of interest and value to those concerned with the reliability analysis of mechanical components. This is an important area which has received less attention than the reliability analysis of electronic components. The emphasis in this report is on the applications rather than on the underlying mathematics. Engineers with a knowledge of basic statistics and the properties of the three distributions should find it quite readable.

When no extrapolation is involved, it will often make little difference which one of the distributions is used to fit the data. Those who extrapolate must always recognize the possibility of obtaining grossly erroneous estimates. ##

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G

Serial Number 2240 -1
ASQC Codes 815;850

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Some notes on construction and application of Poisson operating characteristic functions for equipment MTBF decision-making

AUTHOR: George H. Allen (USAF, AFSC, ESD, Technical Requirements and Standards Office, L. G. Hanscom Field, Bedford, Mass.)

SOURCE: ESD-TR-65-194, Technical Requirements and Standards Office, Electronic Systems Division, Air Force Systems Command, USAF, L. G. Hanscom Field, Bedford, Mass., Mar 65, 11p (AD-613 635)

PURPOSE: To indicate a method of constructing Poisson operating characteristic functions for use in formulating reliability demonstration criteria.

ABSTRACT: To assist in the selection of a permissible number of failures (c value) for a reliability demonstration problem which satisfies certain constraints, it is suggested that Poisson operating characteristic functions be developed. Such functions present, for selected c and test duration values, the probabilities of accepting equipment which has either met, failed to meet, or exceeded an MTBF requirement. For ease of computational presentation, only integral multiples of contractual MTBF are used in assigning a test duration value. In a given demonstration problem, other numbers can be used. A selection of a test duration value depends on such considerations as program schedules, quantities of equipment available for test, availability of test dollars, etc.

The cumulative Poisson function is only one of the statistical models available for application on equipment MTBF demonstration problems. The Poisson approach, with test duration held to a minimum, does not give a high statistical confidence that the contractual MTBF has been achieved or exceeded. However, with the constraints specified in this note, it satisfies the need for a quantitative decision-rule. From the reliability engineering management viewpoint, a one or two multiple of MTBF test with, say, no more than one failure is not considered to be an unsatisfactory procedure. Rather, it could cause contractor management to note the need for delivering equipment for demonstration which has been designed and manufactured for reliable operation, especially, when supplemented by a retest penalty clause which places the complete cost burden of failing the original demonstration on a contractor. Furthermore, the budgeting problem for a fixed test time reliability demonstration is easier to solve than one influenced by a variable test time. (Author in part)

REVIEW: This is a short, clearly-presented paper addressed to the solution of a practical problem in reliability demonstration. Present reliability demonstration models are not satisfactory in situations

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characterized by relatively long MTBFs, limited numbers of items purchased, compressed delivery schedules, and limited budgets. The proposed approach leads to a decision rule which is easily understood, quantifies the risks involved in decisions, and enables scheduling and cost analysis. No claim is made for optimality of the approach, but it does seem to provide a reasonable solution to a practical problem. It does not, however, solve the basic dilemma of proving very long life. ##

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65N28212

Serial Number 2241
ASQC Codes 512;612;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A Monte Carlo technique for obtaining system reliability confidence limits from component failure test data

AUTHOR: Louis L. Levy (Capt., USAF)

SOURCE: Thesis presented to the Faculty of the School of Engineering of the Air Force Institute of Technology, Air University in partial fulfillment of the requirements for the degree of Master of Science, Aug 64, 79p, 23 refs. (AD-610 773)

PURPOSE: To develop a Monte Carlo simulation method for predicting the reliability of complex systems from test data on their components.

ABSTRACT: A digital computer technique is developed, using Monte Carlo simulation based on common probability failure models, with which component failure test data may be translated into system reliability confidence limits at any specified confidence level for systems composed of elements exhibiting different failure patterns. Derivation of predicted confidence limits for such systems cannot be accomplished analytically. Since reliability prediction is generally more meaningful when expressed within a range of values and with an associated confidence that the true reliability is within that range, a valuable and economic tool is provided for the reliability analyst. (Author in part)

REVIEW: The problem of predicting the reliability of a complex system from test data on its components has bothered reliability analysts for some time. Monte Carlo simulation using modern digital computers is a practical solution; and this paper does a good job of presenting the various aspects of this approach. Although a background in probability and statistical theory is assumed, the discussion is quite detailed and adequate references are cited.

It should be emphasized that the Monte Carlo method does not solve the problem of choosing appropriate density functions to represent the times-to-failure of the components. It merely provides an analysis of the network on the basis of given inputs. Thus the success of the method in any practical situation is quite dependent on the choices of underlying densities. This point is not overlooked in the paper--it is mentioned here to emphasize the need for good failure data on components. ##

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10/65 C5 N 24699 Serial Number 2242 -1
ASQC Codes 512;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Confidence limits for system reliability based on component test data

AUTHOR: Oscar Albert Bernhoff (Lt. Col., USAF)

SOURCE: Thesis presented to the Faculty of the School of Engineering of the Air Force Institute of Technology, Air University in partial fulfillment of the requirements for the degree of Master of Science, Aug 63, 73p (AD-425 849)

PURPOSE: To describe a study aimed at determining how confidence limits for system reliability can be obtained from component test data.

ABSTRACT: The exact reliability of a component, sub-unit, or system cannot be measured directly; it must be estimated. Since estimates can vary considerably in their accuracy, it is necessary that limits be attached to their probable range. When these limits are determined with a desired degree of confidence, reliability confidence limits result. These confidence limits add meaning to the reliability figure and provide the necessary information upon which to base reliability decisions.

A procedure, generally accepted and used in the past, has been to obtain the component reliability limits for a given confidence level, combine them in accordance with the series law for reliability, and then use the resulting values as the limits for the system reliability with the same confidence level that was associated with the components. With the advent of small sample testing, discrepancies were discovered and the question arose as to the validity of this procedure. An analysis showed that the above procedure was in error. System confidence limits and their associated confidence level should be obtained by combining the probability density functions for the parameters of the components to get the probability density function for the system.

Series systems composed solely of components having estimators with similar mathematical forms can be solved analytically. When the system reliability expression consists of a combination of dissimilar functions, Monte Carlo simulation must be used to obtain an approximation of the distribution of the system reliability estimator. The procedure consists of sampling the estimator's distributions for dissimilar probability distributions to obtain a sample point in the sample space of the estimator distribution. This procedure is repeated until the system probability distribution is adequately simulated. The accuracy of this method is on the order of 1 over the square root of N, where N is the number of sample points obtained. One thousand and sixty sample points will give a 99% confidence that the simulated distribution does not differ from the analytical distribution by more than .05.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

(Author in part)

REVIEW: This report reads like a preliminary study preceding the report covered by RATR 2241. Since both are theses presented in the same graduate reliability engineering program and they are dated one year apart, the above seems to be a reasonable guess.

A good expository work on this topic would be an important contribution to the literature. This report serves that purpose only up to a point. Too much space is devoted to elementary statistical concepts (in spite of the assumption of a basic familiarity with statistics and probability theory). Virtually no effort is made to tie the discussion in with other published works on the topic (see, for example, RATR 894). The principal conclusion is that the most practical way of finding the approximate reliability distribution for a system is the Monte Carlo technique. ##

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Serial Number 2243
ASQC Codes 872;882

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The standard basic maintainability (M) formulae

AUTHOR: George W. Dauncey (Litton Industries, Guidance and Control Systems Div., Woodland Hills, Calif.)

SOURCE: Presented to Maintainability (M.5.5) EIA Subcommittee, Los Angeles, Calif., 29 Jan 65, 21p, 8 refs. (AD-456 792)

PURPOSE: To present and discuss the basic formulae used in designing maintainability into equipments.

ABSTRACT: This presentation sets forth the basic maintainability formulae, the needs for standardization, the background on which the formulae are based, some examples of their application, and an indication of the benefits to be derived. The need for designers to have simple and usable maintainability quantitative constraints such as "mean time to perform a maintenance action," or "maintenance action rate," and "maintenance allowable time interval" is emphasized.

REVIEW: This will be a useful reference for maintainability engineers and others concerned with designing maintainability into equipment. Generally speaking, the formulae are not rigorously derived but rather presented with some discussion. (A reference to the development of the formulae is cited, however.)

An underlying Poisson distribution of maintenance actions is assumed throughout, with only heuristic justification. Some consideration of just how realistic this is, based on actual data, would be of interest.

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10/65 65N16716 Serial Number 2244
ASQC Codes 821;831;872;
882

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

TITLE: Adaptive statistical procedures in reliability and maintenance problems

AUTHORS: J. L. Gastwirth and J. H. Venter (Stanford University, Dept. of Statistics, Stanford, Calif.)

SOURCE: Technical Report No. 99, prepared under Contract Nonr-225(52) (NR-342-022) for Office of Naval Research, by Department of Statistics, Stanford University, Stanford, Calif., 12 Oct 64, 30p, 11 refs. (AD-608 726; NASA accession number N65-16716)

PURPOSE: To propose several adaptive or sequential plans for intermittent checking of systems having exponential lifetime distributions.

ABSTRACT: Consider a system with lifetime distribution function F(t) which is inspected at times t_1, t_2, ... If inspection reveals that the system is inoperative it is repaired (or replaced); otherwise nothing is done. The problem is to choose the inspection plan (sequence of t_i) in some optimal way. This problem has been considered by Barlow, Hunter, and others (see, for example, RATR 128 and 893) under the assumption that F(t) is known. While not entirely realistic in practice, this assumption leads to statistical questions which have not yet received much attention.

In the present paper the case is considered in which the system has an exponential lifetime with failure rate as an unknown parameter, and several adaptive or sequential inspection plans are proposed. These plans use information, as it becomes available through inspection, to estimate the unknown parameter λ and in this manner approach the plan that would be optimum if λ were known. This idea has already been used by Chernoff and others in their papers on sequential design of experiments to which this paper is related.

The plans proposed in this paper are of two general types, viz., (1) plans based on maximum likelihood methods, and (2) plans based on refinements of the Robbins-Monro stochastic approximation method. The asymptotic properties of these two types of plans are generally the same, but from a practical point of view the latter are computationally simpler and involve storage of a minimum of past information. (References to the related work mentioned above are cited in the paper.) (Authors in part)

REVIEW: This is a mathematical paper which essentially extends the work in the papers covered by RATR 128 and 893. It is a worthwhile addition to the theory in an important topic area. (There seems to be an error in the citation of reference 2 in the paper, as comparison with the source listing on RATR 128 will indicate.) ##

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Serial Number 2245
ASQC Code 823

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Life-testing results based on a few heterogeneous lognormal observations

AUTHORS: A. J. McCulloch (Lockheed California Co.) and John E. Walsh (System Development Corp.)

SOURCE: SP-2038, System Development Corporation, 2500 Colorado Avenue, Santa Monica, Calif., 19 Apr 65, 15p (AD-615 116)

PURPOSE: To investigate the survivability properties of some items of a given kind.

ABSTRACT: During some future period, a number of similar items are to be independently life-tested under "typical" conditions. The observation for each item is its time to failure. The interest is in determining a length of time such that the probability of all the items surviving this long is at least a specified amount. The desired value is to be determined from the results of independent tests on a few items of this type, from supplementary information (tests on similar items), and from a combination of experience and judgment. All observations on items of the type to be life-tested are assumed to have lognormal distributions. The testing conditions are considered to be the same for each of the items to be life-tested later. However, each of the few items that are first considered may be subjected to different testing conditions. A consensus of these heterogeneous conditions furnishes the "typical" conditions that are used for the items tested later. The statistical method consists in utilizing the few observations to allow for mean effects, and in evaluating an upper bound for the variation effects from supplementary information, experience, and judgment. This approach can have strong advantages when there are only two or three observations. (Authors)

REVIEW: There are many life-test situations in which only a very small number of items is available for testing. Thus any approach which enhances the ability to draw valid conclusions on the basis of all the available information is an asset. The approach described in this paper seems reasonable for the type of situation to which the underlying assumptions apply. The paper is a straightforward description of the statistical aspects of the problem. No examples or references are given. One wonders whether in practice the results which this method would yield might not be so conservative as to be of little value. It would be interesting to look into this question with the help of some actual data. ##

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10/65

65A16985
64A20657
64A17285

Serial Number 2246
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Further investigation of a relation for cumulative fatigue damage in bending

AUTHORS: S. S. Manson, A. J. Nachtigall, C. R. Ensign, and J. C. Freche (Lewis Research Center, NASA)

SOURCE: Presented at the Air Transport and Space Meeting, New York, N. Y., 27-30 Apr 64, SAE-ASME paper 843A, 14p, 14 refs. (*Society of Automotive Engineers, Inc., 485 Lexington Avenue, New York, N. Y. 10017)

see also 64X11902

PURPOSE: To investigate the fatigue behavior under two stress levels.

ABSTRACT: The fatigue behavior of several steels, AISI 4130, E52100, and 304 ELC stainless, as well as that of an aluminum alloy, 5456-H311, was investigated in rotating bending fatigue after these materials were subjected to a prestress for different cyclic histories. The data corroborated the authors' hypothesis that lines representing the S - log N relation (median) of a material prestressed in varying amounts will intersect the S - log N median line of the original material near a common point. A correlation was found between the stress at this intersection point and the ultimate tensile strength. Thus the only requirements for establishing the median fatigue behavior of a prestressed material above the endurance limit are the S - log N median line of the original material and the ultimate tensile strength.

The omission from cycle ratio summations of cyclic histories applied below the original, but above the new median endurance limit of a material, was shown for an example to result in a cycle ratio summation less than unity. Cyclic histories so applied can produce damage and must be taken into account. A new hypothesis based upon actual fatigue behavior and incorporating a cycle-ratio-modified-stress-ratio factor is suggested; it holds promise for more accurately predicting the new median endurance limit than most existing methods. Extensive additional tests are required to verify this concept. (Authors in part)

REVIEW: As the authors imply, this is a limited test of the hypothesis. Only two stress levels are considered whereas in most engineering situations there are many stress levels. Attention is confined largely to the median life rather than to the spread in the data. This work is of interest to anyone concerned with the cumulative theory of fatigue damage on an empirical basis.

In a private communication the first author has pointed out that the theory is to be applied to each two consecutive stress levels in a complicated load pattern and that a similar consideration applies to the modification of the S-N curve. For many different stress levels the calculations would become rather burdensome. ##

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64A 20659

Serial Number 2247 -1
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Low cycle fatigue performance of materials in a uniaxial and multi-axial stress field

AUTHORS: S. W. McClaren and J. H. Best (Ling-Temco-Vought, Inc., Aeronautics Div.)

SOURCE: Presented at the Air Transport and Space Meeting, New York, N. Y., 27-30 Apr 64, SAE-ASME paper 843B, 16p, 7 refs. (*see RATR 2246)

PURPOSE: To investigate the low cycle fatigue of two stainless steels, a titanium alloy and a Maraging steel, both in uniaxial and biaxial stress.

ABSTRACT: The uniaxial and biaxial characteristics of full-hard cold-rolled 301 stainless steel; AM-355 stainless steel (SCT condition); annealed 6Al-4V titanium alloy; and 300 Series Maraging steel have been evaluated under repeated loads at high stress levels to produce low cycle fatigue failures.

Fracture analysis is included for material characteristics such as K_{c1}, a fracture toughness parameter; a method of assessing fatigue damage as a function of plastic strain accumulation is explored.

The test specimens included standard uniaxial test elements, a cross-shaped biaxial specimen, cylindrical pressure vessels, and standard center-notch fracture toughness specimens. Results of the tests are discussed in light of failure theories to determine the most practical procedures for predicting fatigue life.

The following conclusions are drawn.

1. The biaxial cross-shaped specimen has been shown to be very satisfactory for determining biaxial static and low cycle fatigue properties.
2. The S-N curves for low cycle uniaxial and biaxial fatigue data illustrate that the 1:1 state of stress is usually the most severe with the relative severity of the 2:1 and uniaxial states of stress being a function of stress magnitude and R factor conditions.
3. The basic prediction of fatigue life for uniaxial and biaxial states of stress can be summarized by saying that:
   (a) At very high stresses (97% NTS or higher) the deformation energy theory concept compares very closely to experimental results.
   (b) At lower stresses the failure theory changes to a much more severe theory because biaxiality effects seem to be creating greater damage than at the higher stresses.
4. The method of assessing damage by strain accumulation is interesting; however, further verification is required. The potential usefulness of relating damage to an actual material

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property is, of course, the primary objective.

5. The differences in biaxial fatigue characteristics of "shear-formed" and "as-rolled" sheet materials have affirmed the significance of manufacturing processes and the degree of plastic deformation imparted to materials before the material reaches final application.

6. The effective use of the theoretical equations of elasticity and plasticity while employing a sheet material-type biaxial stress specimen under closely controlled test techniques has resulted in a general test concept that can be used to test materials in sheet form under biaxial states of stress.

A table is given for ranking materials in this type of service. (Authors in part)

REVIEW: There appears to be little agreement in the literature, as yet, on the descriptions of low cycle fatigue. This is another valuable contribution to the field. ##

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64A20549
65N35205

Serial Number 2248 -1
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The prediction of notch and crack strength under static or fatigue loading

AUTHOR: Paul Kuhn (Langley Research Center, NASA)

SOURCE: Presented at the Air Transport and Space Meeting, New York, N. Y., 27-30 Apr 64, SAE-ASME paper 843C, 10p, 17 refs. (*see RATR 2246)

PURPOSE: To present a method for predicting fatigue or static strength notch factors for notches of any acuity in metal parts, using as a basis conventional tensile properties and a "Neuber constant" which expresses size effect.

ABSTRACT: The method and formulas are first given and then critically discussed. This method of notch analysis is based on the conventional concept that a notched part will fail when the peak stress at the root of the notch becomes equal to the appropriate "failure stress." The peak stress is calculated as the product of the net section stress and an appropriate factor of stress concentration.

This method of notch analysis demonstrates the capability of predicting fatigue notch factors as well as static strength notch factors, utilizing as a basis conventional tensile properties and a "Neuber constant."

For low-alloy steels, wrought aluminum alloys, and titanium alloys, Neuber constants have been defined by curves and may thus be regarded as known. For aluminum alloys, it has been shown that the Neuber constants may be used to compute either fatigue or static notch factors. At present, Neuber constants for low-alloy steels may be used only for fatigue notch strength calculations, while the constants for titanium alloys may be used only for static notch strength calculations. Additional research is needed to determine whether the constants for low-alloy steels and for titanium alloys can be used in the same general manner as for aluminum alloys. For stainless steels, successful applications to the problem of static notch strength have been made, but the Neuber constants must be obtained on an individual basis.

The method of notch analysis is intended chiefly for use in fatigue design and in the strength analysis of structures containing cracks. It permits greatly increased use of the information on notch strength and crack strength of materials, since it affords reliable comparisons between tests made on specimens of widely different widths and with different types of notches. It also aids in making a more rational choice of specimens for notch testing and will permit a great reduction in this type of testing. The scope of the method has been greatly extended by equations which make it applicable to cylinders and to stiffened sheet.

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

The problem of static notch strength of thick sections in all materials should be investigated. Methods of taking strain rate effects into account should be developed, and correlations with transition temperature data should be established to round out the picture. (Author in part)

REVIEW: This is an area with which many engineers doing design may be unfamiliar. This paper will not be easy to read unless some reasonable background is possessed already. As with so much research these days, there are not enough data to make full use of it, but it is nevertheless very useful in guiding the more efficient accumulation of numbers. This research is restricted to sheet metal structures, but the reduction of strength due to cracks is very important, especially since some of the higher "strength" materials have quite poor crack properties. ##

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10/65 *64A20752*

Serial Number 2249
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Predicting reliability of supersonic propulsion systems

AUTHORS: J. J. Eden (Trans-Canada Air Lines) and R. S. Stahr (American Airlines, Inc.)

SOURCE: Presented at the Air Transport and Space Meeting, New York, N. Y., 27-30 Apr 64, SAE-ASME paper 848A, 9p, 6 refs. (*see RATR 2246)

PURPOSE: To mention some engineering problems in jet engines.

ABSTRACT: Supersonic propulsion systems are much more complicated and difficult than subsonic ones. The conditions of operation are more severe and less is known about them. Engineers should do extensive design analysis both to eliminate trouble before the hardware stage and to ease the corrective burden should it develop. Detection of incipient failures is an important way of extending reliability. If the actual maintenance requirements can be estimated, it makes the cost picture a lot clearer. An example is given of trouble in a subsonic jet engine. Since there will be fewer supersonic transports, the airlines will have to pool their maintenance experience if they are to be successful. It would be good for them to begin now on the present aircraft.

REVIEW: The word reliability as used in this paper is so fraught with diverse connotations that it is difficult to follow parts of the discussion. Perhaps if some of the reliability work were simply referred to as engineering it would help. As long as engineers do not completely understand their materials, systems, and environments they will not be able to calculate accurate survival probabilities as functions of time. They can, however, much more easily predict that removing a stress concentration will improve the life. Of course, they sometimes fail to account for negative side effects. Both the quantiative and better/worse aspects are part of engineering, or reliability engineering. But the latter is rarely referred to as predicting reliability. In the absence of applicable past experience of some sort, it is impossible for engineers to do any more than guess at lifetimes, especially where the variability between parts can be very high.

This paper deals little either with predicting reliability or with supersonic propulsion systems per se. It is nonetheless valuable in pointing out some engineering problems and ways of approaching their solution. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An airline approach to reliability

AUTHOR: J. E. Conner (Pan American World Airways, Inc.)

SOURCE: Presented at the Air Transport and Space Meeting, New York, N. Y., 27-30 Apr 64, SAE-ASME paper 848C, 7p (*see RATR 2246)

PURPOSE: To present a brief history of reliability activities within the airlines and to discuss some new approaches representing joint efforts of the airlines and the Federal Aviation Agency.

ABSTRACT: The airlines want to use the life of aircraft parts as fully as possible without expensive overhauls which are based on too short a time basis. Together with the FAA they have developed the "alert" system wherein the overhaul period can be extended if the failures during that period are not too numerous and the extension looks promising. This program is on an industry-wide basis for jet engines and is doing well. Pan American is extending it to other parts of the aircraft which can be easily handled in this way. The use of statistics is gradually becoming more sophisticated. It is expected that repair costs can be appreciably reduced without adversely affecting safety.

REVIEW: The parts of the paper are good that treat example problems and how the airlines are dealing with them. Unfortunately the word "reliability" has so much associated semantic confusion that it is not always possible to tell what is meant. For cost reasons, the airlines wish the scheduled time between overhauls to be as long as possible without risking aircraft safety. A large part of the paper deals with how to accomplish this situation. Where the part failure does not jeopardize the flight, operating to failure is usually the best strategy. The "alert" system, approved by the FAA, is mentioned as a working plan in many situations, but the reader is presumed to be already familiar with it. The infant mortality after overhaul is high and this means that there is a reliability incentive not to overhaul in many cases. (The term "random" failure is used to mean Poisson behavior.) ##

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64A 20456

Serial Number 2251
ASQC Codes 830;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Keeping pace with jet transport requirements through product improvement

AUTHOR: L. W. Vance (Vickers Inc., Aerospace Div.)

SOURCE: Presented at the Air Transport and Space Meeting, New York, N. Y., 27-30 Apr 64, SAE-ASME paper 850B, 8p (*see RATR 2246)

PURPOSE: To describe an approach to aircraft part improvement.

ABSTRACT: Given sufficient safety, reliability and maintainability should be at the point for minimum overall costs. Laboratory tests and analysis can show if a redesigned part is probably going to be satisfactory. Field tests are instituted as soon as laboratory tests are looking good. Tooling is undertaken as soon as the field tests look good enough. In some cases where the change is minor and engineering considerations point to improvement with no induced problems, all that is required of field tests is that they do not show up bad. Plotting of cumulative failures on Weibull paper is a good enough analysis for life characteristics. A mean failure rate over 3 months or 6 months is a good indicator of field performance. Charts are suggested for quick analysis of failure behavior.

REVIEW: This is a good general article. There is little mathematics or statistics in it or used in the proposed analyses--but there is as much as the data warrant. The philosophy of product improvement appears quite adequate. ##

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Serial Number 2252
ASQC Codes 830;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

64A 20844

TITLE: Designing reliability into jet transport hydraulic systems

AUTHOR: R. E. Middleton (Lockheed-California Company)

64A 20370

TITLE: Improved reliability in transport aircraft hydraulic systems

AUTHOR: George F. Moore (Trans World Airlines, Inc.)

SOURCE: Presented at the Air Transport and Space Meeting, New York, N. Y., 27-30 Apr 64, SAE-ASME papers 850A and 850C, 6p each (*see RATR 2246)

PURPOSE: To discuss the causes of hydraulic system failure and the measures taken for eliminating them.

ABSTRACT: The hydraulic systems of aircraft have graduated from part-time to full-time use. Their reliability is more important than ever to aircraft safety. Loss of fluid caused by faulty equipment or poor handling by ground crews is one of the most important problems. The bends in the tubing, tubing supports, induced vibration, fittings, and seals all cause trouble; all are being improved. The pumps themselves may fail; cleaner fluid, fewer pump seals, better lubrication, and modified design are some of the methods for correction. Filtering the system to a few microns can be difficult and expensive. Indicators for clogged filters are helpful but can cause false alarms. Cleaning the metal elements is a tricky business. The nature of the fire-resistant fluid causes all sorts of problems in and out of the system. Correction of the fitting problem is coming about with modular design wherein many components are prepackaged into an easily-serviced module. Infinite attention to detail in design, installation, and service is required for high reliability.

REVIEW: Both of these papers are good in calling attention to the need for improvement in reliability of hydraulic systems. They review the progress that has been made without either becoming complacent or complaining. The question of cleaning of filter elements is a difficult and thus controversial one (see RATR 1881). Also there is some consideration being given in some areas to a careful review of the total worth of the non-flammable vs. flammable fluids since the former are not an unmixed blessing. Both papers point out the absolute necessity of attention to detail--a most valid point. ##

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Serial Number 2253 -1
ASQC Codes 720;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Interconnection techniques for microcircuits

AUTHORS: F. Z. Keister, R. D. Engquist, and J. H. Holley (Hughes Aircraft Company, Culver City, Calif.)

SOURCE: IEEE Transactions on Component Parts, vol. CP-11, p. 33-41, Mar 64 see also 64A 22008

PURPOSE: To describe the material, equipment, and processes involved in interconnecting microcircuits.

ABSTRACT: Twelve interconnection techniques are described:

1. Soft soldering
2. Resistance welding
3. Series welding
4. Parallel-gap welding
5. Ultrasonic welding
6. Thermocompression bonding
7. Electroplating
8. Conductive adhesives
9. Deposited films
10. Percussive arc welding
11. Electron beam welding
12. Laser welding.

No single technique appears suitable for all applications. The two techniques predominantly used in today's microcircuitry production are soft soldering and resistance welding. Over the years, these two methods have proven their reliability. The initial equipment cost is reasonably low, highly skilled personnel are not required, and training time is short. Laser welding and electron beam welding, on the other hand, are still under laboratory evaluation. These two interconnection techniques offer more long-range potential than most of the other techniques, but they do require fairly expensive equipment and well-trained personnel. The end result (i.e., the microcircuit interconnection) can be duplicated and repeated with high precision since the processes are machine controlled. Thermocompression bonding, due to its capability of producing small diameter ohmic interconnections, is applicable for the smallest of microcircuits; however, the joint strength is very low and therefore must be protected or sealed in some manner. It does offer a means for making attachments directly to semiconductor or delicate thin-film substrates.

Techniques such as parallel-gap welding, series welding and ultrasonic welding are gradually gaining acceptance for interconnecting lead wires or ribbons to both microcircuit wafers and to etched circuit boards. The initial equipment cost is moderate and semi-skilled personnel may be used. Ultrasonic welding in particular

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affords a method of interconnecting microcircuits where one or both of the joint materials is aluminum. Microcircuit interconnection techniques, such as electroplating, conductive adhesives and vacuum-deposited films, are primarily applicable for the attachment of discrete microcomponents (either with or without leads) to thin film circuits or miniaturized-etched circuits. With these techniques, all of the interconnections can be made simultaneously without worrying about heat, pressure and joint materials as one does in soldering and welding. Percussive arc welding, another interconnection technique still under laboratory investigation, is applicable to the termination of microcircuit packages to "mother" boards or to connectors especially where a butt-type weld is required. (Authors in part)

REVIEW: This paper is a good, well illustrated review of the state-of-the art. The microcircuits considered and/or illustrated are primarily of the thin-film or hybrid type rather than silicon integrated circuits. No discussion of the importance of packages or encapsulation is included.

Nine of the techniques considered (1-6, 10-12) are methods of joining two metal conductors, while the other three describe methods of incorporating a metal lead into a surface layer on top of a substrate. These techniques are not necessarily interchangeable or even parallel steps in alternative schemes of interconnections.

The discussion of thermocompression and "nail head" bonding implies that wires contact the semiconductor directly. In devices made of silicon an intermediate aluminum or gold layer is generally present and it is to this layer that the wire actually bonds rather than to the silicon itself. The Kulicke and Soffa Microcircuitry Bonder Model 4016, referred to in this section, does not exist; most likely Model 401 is meant. ##

Serial Number 2254 -1
ASQC Codes 711;713

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Effect of composition and microstructure on the low cycle fatigue strength of structural steels

AUTHORS: R. D. Stout and A. W. Pense (Lehigh University, Metallurgy Department, Bethlehem, Pa.)

SOURCE: Transactions of the ASME-Series D, Journal of Basic Engineering, vol. 87, p. 269-274, Jun 65 (Paper No. 64--Met-9)

PURPOSE: To report on correlations between low cycle fatigue strength of structural steels and their more-easily ascertained properties.

ABSTRACT: In a number of studies of data obtained from fatigue tests on various materials it has been shown that the number of cycles to failure is related to the strain range by a relationship of the form

$$\epsilon N^m = c$$

where N is the number of cycles to failure, ϵ the strain range, and M and c are constants. In the low cycle portion of the strain range versus cycles to failure curve, evidence has been presented by several investigators to show that the relationship should be

$$\epsilon_p N^{\frac{1}{2}} = c$$

where ϵ_p is the plastic strain range and c, the constant, can be related to tensile ductility. Some investigators have found the relation

$$\epsilon_t N^m = c$$

more useful. Here ϵ_t is the total strain range. As a result of a series of Pressure Vessel Research Committee investigations at Lehigh University, a large body of low cycle fatigue data has been obtained for a wide range of steels, microstructures, heat-treatments, and testing conditions. A study of these data has been undertaken, with special emphasis on the suitability of a relationship of this type for analysis and representation of fatigue data. As a result of this study the following conclusions have been drawn: (a) In the range of 5000 to 100,000 cycles a relation $\epsilon_t N^m = c$ appears to be satisfactory. (b) Using this latter relation, an analysis of the low cycle fatigue behavior of structural steels reveals that they can be classified into three broad groups on the basis of their composition. Each group has a characteristic value of m and c which can be used to predict their behavior over the range 5000-100,000 cycles. (c) The value of m and the total strain for 5000 cycle life can be related to n, the strain hardening exponent, for the steels. The total strain for 100,000 cycle life is related to the ultimate

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tensile strength of the steels. Using these relationships, the fatigue curve for a structural steel can be estimated from tension test data. (d) The effect of microstructural variations for a steel within any one of the three groups was of secondary importance when compared to the compositional groupings, although some systematic effects of microstructural variations were noted. (Authors)

REVIEW: The material in this paper is a valuable addition to designers' knowledge. The correlations seem reasonable and the discussion is well founded. It should be borne in mind that the tests were on unnotched fatigue specimens and not on pressure vessels themselves. ##

10/65

Serial Number 2255
ASQC Codes 711;770

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Crankshafts should be broken in the laboratory instead of the engine

AUTHOR: Donald E. Niles (Outboard Marine Corporation)

SOURCE: Engineering Know-How in Engine Design (Part 12), SP-256, published Jun 64 by the Society of Automotive Engineers, Inc., 485 Lexington Avenue, New York, N. Y. 10017, p. 15-22

PURPOSE: To describe some crankshaft testing procedures.

ABSTRACT: A crankshaft is an awkward item for many of the routine stress analysis procedures. Finding the points of highest stress can be done with brittle lacquer if simulated loading is permissible. If not, some ceramic coatings can be used, or, possibly, weaker materials. Strain gages can be located at these points and the operating stresses measured (the stress varies rapidly with distance; the gage will give some average stress indication). Slip rings are a problem and a special design is described. The fatigue limit was determined at 35 million cycles for five shafts; this was later dropped to 15 million and three shafts. The Prot method was also tried with some success.

REVIEW: This is a straightforward applications paper. The material of the shafts was not mentioned; if it was steel, then 10 million cycles is generally accepted for the fatigue limit. On the other hand, a non-zero fatigue limit does not exist for aluminum alloys. The Prot method does have some serious disadvantages; the best exponent is not always 1/2. If rather different materials, treatments, or geometries are compared, much of the data should be in the region of interest because the fatigue curves could easily cross at moderate loads. ##

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Serial Number 2256
ASQC Codes 821;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability goals--the effect of dependency

AUTHOR: Howard L. Leve (Douglas Aircraft Company, Inc., Missile & Space Systems Div.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 19-26 (*cosponsored by AIAA, SAE, and ASME; volume of technical papers available from Society of Automotive Engineers, 485 Lexington Avenue, New York, N. Y. 10017; SP-246, Member price $9.00, Nonmember price $13.50)

PURPOSE: To show that the calculated system reliability can be higher if correlations between stresses on the elements are taken into account.

ABSTRACT: If the stresses on two elements have a correlation of +1, if the strength of each is fixed, and if the strengths are adjusted so that the prob(failure of A|failure of B) = prob(failure of B|failure of A) = 1, then the reliability of the system of two elements in series (logically) is just the reliability of one, not the product of the two element reliabilities. Thus, for a given system reliability, the two parts can be designed to be weaker than if the incorrect formula (which does not include correlation) is used.

REVIEW: Some of the conclusions in this paper are very good, viz. that correlations between stresses should be taken into account since the reliabilities of individual elements can then be reduced and the system can still have the same overall reliability. But after giving an illustration of the validity of this concept, the author then ignores it by asserting that dominant failure modes are independent. It helps when using the word "independence" to qualify it as physical or statistical (the latter is usually meant by this author). The "life history" part of the paper seems needlessly belabored. The simple assertion that strength is independent of time (i.e., no damage accumulates due to stresses) would be sufficient. The paper covered by RATR 199 gives the essence of this paper, and does so more concisely. ##

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Serial Number 2257
ASQC Codes 814;844;850

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Maximizing reliability demonstration for a given expenditure

AUTHOR: B. L. Amstadter (Aerojet-General Corporation, SNAP-8 Div.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 38-42 (*see RATR 2256)

PURPOSE: To provide a method for achieving maximum reliability demonstration for a given expenditure, or its equivalent, attaining the minimum expenditure for demonstrating a given level of reliability.

ABSTRACT: The objective of maximizing the ratio of demonstration to cost is achieved by testing a greater number of the less expensive components which comprise the system, rather than testing the same quantity of each component. The two factors involved are the degree of reliability demonstration and the direct testing cost. Reliability is stated in terms of the failure rate associated with the standard exponential law. Testing cost is the direct cost of testing the article, including the costs of test items and of time of test personnel, which are both proportional to the number of articles. The demonstrated failure rate and the direct testing costs of a component type are related, and the results are used to determine relative quantities of each component type that should be tested. Resulting procedures are demonstrated with an example.

REVIEW: This is essentially a "cost-effectiveness" type of approach to a reliability demonstration test. In this paper the conventional assumptions of a constant failure (hazard) rate and independence between components are used. The treatment of the manner by which test results are used to statistically estimate failure rates and associated confidence limits of components and the system is sketchy. No references are cited. The specific development and presentation here does not inspire confidence in the results, but this approach is worthy of consideration by anyone planning a reliability demonstration test for systems which can be divided into components suitable for testing. ##

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10/65 63A16118

Serial Number 2258
ASQC Codes 821;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: System reliability over an operational spectrum

AUTHOR: Howard L. Leve (Douglas Aircraft Company, Inc., Missile & Space Systems Div.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 51-58 (*see RATR 2256)

PURPOSE: To develop formulas for obtaining the reliability of a system over a set of possible life histories.

ABSTRACT: It has been found previously for a simple time independent failure mode case that the life history of an element is characterized by conditions existing at the instant of minimum element reliability. This result is extended to include the cases of time dependent failure modes, multiple failure modes per element considering strength dependency, and time variable strength distributions. The last situation leads to the concept of failure condition as a generalization of the meaning of a failure mode. The collection of the conditions characterizing the life histories of the elements form a complete description of the system history. The expression for obtaining the reliability of a system over a life history from its element reliabilities appears in classical probabilistic form, without regard to the time-wise characteristics of the history. (Author)

REVIEW: While many of the author's conclusions are valid, they are reached in a rather tedious manner. It is not difficult to apply probability theory to mission reliability in such a way that it is obvious that the time of failure during the mission is of no importance and that failure has occurred if any failure mode of any necessary element has occurred. That is about all that is shown, other than that cumulative damage can be put into the stress-strength phraseology. The author's final section on an approximation for the system reliability is incorrect. Equation 39 contains a fundamental error in the treatment of conditional probabilities, which is abetted by the shorthand notation. ##

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Serial Number 2259 -1
ASQC Codes 831;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

63N10493

TITLE: A study of rocket engine system reliability

AUTHORS: P. H. Raabe and A. J. Mihanovich (Aerojet-General Corporation, Reliability Div., Liquid Rocket Plant)

SOURCE: Report No. 0599-01F, Volume 1, prepared by Aerojet-General Corporation, Liquid Rocket Plant, Sacramento 9, Calif. for Office of Research Grants and Contracts, NASA Headquarters, Contract NASr-66, 16 Oct 62, 121p, 9 refs. (AD-459 288; NASA accession number N63-10493)

... 63A16119

Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 59-71 (*see RATR 2256)

PURPOSE: To define and present methods for evaluating inherent reliability of a design.

ABSTRACT: Special problems associated with liquid rocket development were analyzed to provide a background for a reliability predicting technique. This analysis indicated that for reliability purposes, the engine contractor is limited primarily to data obtained from static engine tests, with limited inputs derived from vehicle integration and flight tests. In addition, the interpretation of the resultant data caused special problems associated with deriving reliability information. Since engine tests are generally terminated immediately upon the failure of any component, the interpretation of operating components on these tests is difficult.

The concept of inherent reliability was then analyzed. Inherent reliability is associated with the design of an item and thus can never be observed directly because the item is subject to various degradations through use. Furthermore, the inherent reliability can be changed only by changing the design itself. From such considerations, a set of ground rules was evolved to establish a technique for predicting inherent reliability. The technique is intended for use during the preproposal, proposal, and early development phases as a means of predicting the inherent reliability increase anticipated during later phases of the development program.

The basis of the technique is the assumption that liquid rocket engines consist of essentially similar components, and that if inherent reliabilities can be associated with certain basic components, a technique would be available for developing inherent reliability estimates for liquid rocket engines.

The development of the technique consisted of partitioning liquid

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

rocket engines into basic component types. For each component type, applicable engine static test data were accumulated. Each static test firing was divided into distinct periods: prefire inspection, start transient, steady-state firing, and postfire inspection. On the basis of an analysis of the historical data, inherent reliabilities were associated with each of the test periods for each of the component groups. The result was a procedure for estimating component inherent reliabilities.

A mathematical model was developed to relate the component reliabilities to the system reliability. The model has distinct advantages over previously-used models because it accounts for component dependence or interactions; these factors are usually assumed to be negligible in order to simplify the analysis.

The technique was applied to several simulated missions, showing versatility for various missions. (Authors in part)

REVIEW: The paper (second SOURCE) is virtually lifted intact from the report (first SOURCE), although the report is merely listed as a reference for a derivation in the paper. The term "inherent reliability" is unfortunate since it implies something that is not there. A useful concept is present, however, even though it is not defined in a clear-cut way. All phases of the product cycle are necessary and each makes its good and bad contributions to the product behavior. In this case, inherent failures seem to be those which cannot, in good conscience, be assigned to something other than the design group.

Both the paper and the report are generally good, clear descriptions of what was done and why. Several times the term "independent" is used without qualification as to whether physical or statistical independence is meant; without the modifier, "independent" is ambiguous. The formula for system reliability in terms of component "reliabilities" can be written in another form:
$u_s/r_s = \sum_i U_i/R_i$ where $U = 1-R$. This is easily transformed to
$F_s/S_s = \sum_i F_i/S_i$ where F and S are numbers of observable success and failure events.

In the formulas for mission reliability, it is assumed that all the events are statistically independent, although it is not clear why it should be so. ##

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Serial Number 2260
ASQC Codes 813;817;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Evaluation of trade-offs between reliability, performance, schedule, and cost

AUTHOR: F. W. Diederich (Avco Corporation, Research and Advanced Development Div.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 72-87, 8 refs. (*see RATR 2256)

PURPOSE: To discuss the definition of trade-offs involving reliability and their use in defining a system or a program which is relatively complex and which requires some advance in the state of the art.

ABSTRACT: The methods for evaluating internal trade-offs between performance, cost, schedule, and reliability are discussed, and examples are given. Methodology of system optimization and some of the problems encountered are presented. A brief discussion of external trade-offs is then given. Lastly, the use of trade-offs in program management is discussed, with reference to program definition, to monitoring of technical progress, and to rational determination of performance-incentive for schedules. Extensive and intelligent use of computers is required for greatest effectiveness. The concepts described are quite sophisticated and at times require a fair amount of idealization of the actual situation to be of use in practical problems. However, the techniques have been successfully used in the past, and as experience leads to simplifications they may be expected to become an accepted part of systems analysis and program management methodology. (Author in part)

REVIEW: Concepts currently referred to as system and cost effectiveness are presented in an expository manner. This is a lengthy but good discussion of the rationale of effectiveness concepts. Most of the paper is qualitative discussion, although several basic mathematical models are presented. Limitations and practical problems are liberally cited. Implications are that the author has been involved in realistic applications of the concepts, although no examples are developed and presented. RATR 1954, 1955, 2175, and 2200 cover papers on the same subject. ##

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63A16121

Serial Number 2261
ASQC Codes 824;831;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: New concepts in the prediction of mechanical and structural reliability

AUTHOR: Arnold A. Rothstein (Avco Corporation, Research and Advanced Development Div., 201 Lowell Street, Wilmington, Mass.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 91-97, 11 refs. (*see RATR 2256) (also AD-459 838) 6

PURPOSE: To present the concepts and methodology for three new reliability prediction techniques.

ABSTRACT: Of the concepts discussed in this paper, the first is the use of functional failures rather than part failures to describe system failure. A functional failure is called a failure therblig and might be brinnelling or leaking, for example. By analyzing many system failures, the functional failure rates and their weighting factors can be determined.

Where system equations are available, the mean and variance of the performance can be obtained by a Taylor's series expansion of the equation. The limitations here, of course, are knowing the equation and the ignoring of higher-order terms. Where system equations are not known, they can sometimes be developed empirically.

REVIEW: This paper serves to give a rough idea of the three methods, but it does not go into accurate detail on each one. The failure-therblig approach does not seem to have caught on. The linearizing of an equation by a Taylor's series expansion is rather conventional in many fields. The property reliability method is just a matter of generating an empirical performance equation. It should probably be developed about some average reference as in the second method.

In general, the paper contains enough misprints to be annoying to read; there are some inaccuracies such as the use of the expression "statistically independent" when "uncorrelated" is correct; some of the descriptions of failure therbligs do not make sense. ##

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Serial Number 2262
ASQC Codes 814;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability and relative cost of steam turbine governing and stop valve arrangements

AUTHORS: Dimitri Kececioglu and Roy C. Hughes (Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 98-105 (*see RATR 2256)

PURPOSE: To describe an application of reliability-cost appraisals for the optimization of commercial power system designs.

ABSTRACT: The relative reliability of five steam turbine governing and stop valve arrangements are mathematically determined. Actual valve reliabilities are determined from field performance data, and the expected number of failures for each arrangement over the life of a turbo-generator set is calculated. Costs which are considered are initial, system failure, maintenance and downtime. The arrangement giving the minimum relative total cost is arrived at, and drastic variations of the input values do not change the choice. This analysis indicates that today's predominant practice of physically putting stop valves in parallel should be replaced by the use of series valves. The increase in mission time due to the inability to periodically fully cycle the stop valves except during periods of shutdown is more than offset by gains in initial price, overall system reliability, and reduction in system failure cost. (Authors in part)

REVIEW: Reliability analysis techniques developed under the impetus of military and space needs are finding increased applications in commercial programs. Acceptance of reliability techniques in the commercial environment is probably the highest endorsement which could be made attesting that these analyses are worth the effort. In this paper only elementary reliability models are used, and they seem to yield useful results. Optimization is arrived at by considering five different practical system arrangements and no elaborate optimization techniques are used. It is encouraging to see that more engineering educators are working in reliability. Hopefully, they are also introducing these techniques into the engineering curricula. ##

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63A16126

Serial Number 2263
ASQC Codes 813;815;851

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Guaranteed reliability using incentives and penalties

AUTHORS: Edward J. Cherian (Air Force Systems Command, Aeronautical Systems Div.) and Lionel Levy (Republic Aviation Corporation)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 144-150 (*see RATR 2256)

PURPOSE: To describe the contractual formulation of a reliability test program associated with an incentive contract which was applied to a number of electronic sybsystems of the F-105 weapon system during their production phase.

ABSTRACT: Initial requirements for the F-105 weapon system did not contain reliability requirements, and the integrated electronics system proved in operation to be the principal source of unreliability. Several approaches were considered in order to significantly improve the reliability of the F-105. The approach selected was a reliability incentive contract with proof of numerical reliability attainment through testing under simulated use. The many peculiar technical and administrative problems attendant upon such a program are enumerated. Some of the many problems encountered and discussed are: (1) equitable incentive and penalty plans, (2) statistical interpretation of test outcomes, (3) definition of reliability test environment and of failure, (4) test facility tie-up, and (5) effect on production flow and stock control. Both the customer and contractor give their individual points of view. (Authors in part)

REVIEW: Emphasis here is on the problems encountered in a reliability test which is used to measure reliability under an incentive contract. It is a good discussion based on the realities of an actual implementation, rather than a hypothetical discussion. This approach to reliability measurement is suitable where reliability is low enough and the number of systems large enough to obtain statistically meaningful data under simulated use environments. There have also been reliability measurements associated with incentive contracts where actual system field operation is used for reliability measurement. (See, for example, RATR 1955 and 2264.) A follow-up paper presenting further experience and an analysis of the resulting data would be worthwhile. Those interested in reliability demonstration tests and incentive contracts will want to see this paper. ##

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Serial Number 2264
ASQC Codes 813;815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability management of an incentive contract

AUTHORS: S. N. Lehr (Space Technology Laboratories, Inc.) and Capt. W. S. Durham (United States Air Force)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 185-189 (*see RATR 2256)

PURPOSE: To explain an incentive contract used for an earth satellite as an example of the trend in space age management toward Cost Plus Incentive Fee contracts.

ABSTRACT: The period of Cost Plus Fixed Fee as a sole contracting method for the space age has ended, and the Cost Plus Incentive Fee contract is now with us. The government's aim is to reward extraordinary performance with a means of earning greater profits and correspondingly to reduce profits for a less-than-desired performance. An incentive contract for an earth satellite is discussed. Here the total incentive is divided between cost and performance, with the performance profit incentive greater than twice the cost incentive. Performance includes results of: (1) in-plant reliability tests in a space-simulated environment and on-stand operations, (2) successful demonstration of orbit injection, and (3) lifetime in orbit. The negotiated contract specifies that the contractor must establish and maintain a comprehensive reliability and quality assurance program. An Air Force project officer has prime responsibility for reliability and quality assurance. Twelve reliability program elements are discussed. There is a lot at stake in this program; the contractor can make a good profit or a loss depending upon achieved reliability. (Authors in part)

REVIEW: This paper consists essentially of a brief description of the incentive contract rules and of the elements of the reliability program. There is little discussion of the reasoning behind the particular reliability and other incentive rules, nor of the experiences and problems of implementing the contract and the program. The particular satellite program is not identified and no references are given. ##

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Serial Number 2265
ASQC Code 810

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A manufacturer's corrective action system for reliability control

AUTHORS: Charles H. Kohler, Jr. and Walton Y. Cook (Lockheed-Georgia Company, Division of Lockheed Aircraft Corporation)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 190-197 (*see RATR 2256)

PURPOSE: To present the development, implementation and operation of a workable corrective action system.

ABSTRACT: Corrective action is a basic need for management of normal business. Experiences are presented which are based on the efforts of a large aerospace company to strengthen its corrective action approach and thereby increase the reliability, quality, and producibility of its end products. In this system, problems are detected and corrected without placing emphasis on the exposure of people who are undoubtedly involved. Factual data are placed in the hands of a responsible organization which is charged with taking concise, positive, corrective action. Evaluation should be taken to confirm that a permanent "fix" has been provided. The basic ground rules and practical limits which must be established are discussed; included are definitions, organization groups, and control factors. Steps which are to be taken in developing and implementing a system are recommended. (Author in part)

REVIEW: The subject matter here is more "quality control" than "reliability" in terms of what these functions usually do in a contractor's organization. This paper is an enthusiastic discussion of corrective action systems. As any contractor working under current government requirements would already have a system, most of this will not be new material. However, it is a thorough presentation and those persons working with corrective action for manufacturing operations might find some ideas here. ##

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Serial Number 2266
ASQC Codes 822;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Automotive component reliability based on the Weibull and log-Normal methods

AUTHORS: Ned Fuller (Ford Motor Company, Transmission & Chassis Div.) and Charles Lipson (University of Michigan)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 211-215 (*see RATR 2256)

PURPOSE: To compare the usefulness of the Weibull and log-Normal distributions in deciding which process is best and to investigate the sample size problem.

ABSTRACT: A cast housing was selected for these experiments and two designs were tested, 20 of the first and 16 of the second. Both the Weibull and log-Normal plots showed that design #2 was the best and that design #2 was the more uniform in life (the tests were in fatigue). Several graphs were drawn of the median life, in these tests, as a function of cumulative sample size.

REVIEW: As is often true, little preference is shown for one distribution over the other for small sample sizes. The answer in this case was obvious from a histogram of the life data. The value of the plots concerning median life is not clear since few people are concerned with the relative values of designs at 50% failures.
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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability prophets versus profits

AUTHOR: L. W. Reid (Sperry Rand Corporation, UNIVAC Div., Univac Park, St. Paul 16, Minn.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 263-267 (*see RATR 2256)

PURPOSE: To discuss the problems in achieving the goals of reliable equipment and quality products in addition to the desire of management to make a profit and stay in business.

ABSTRACT: Experience has indicated that the basic cause of unreliability of electronic systems is error in the manufacturing process of parts and assemblies. The problem is how to organize to perform essential reliability tasks such as failure analysis and to obtain the necessary feedback to the source of the problem so that positive corrective action can be achieved. When the call for increased reliability went out, industry reacted by creating super-organizations. Many line functions of engineering and manufacturing were assigned to these groups. The customer encouraged the development of these groups, until it is not uncommon to find a ratio of 1:1 between design personnel and reliability personnel. In addition, new groups such as value, maintainability, and human engineering have appeared; all are justified by various problems and specifications. The natural result of all this is the situation where we have groups watching groups which watch other groups. Recently there has been a ground swell of criticism toward these approaches. However, the reliability and quality of electronic systems have improved. The problem of financing these groups remains, for even though reliability and quality requirements are spelled out, the procurement agencies do not seem able to understand the large number of dollars which are required to comply. Careful bidding to the letter of specifications generally results in a non-competitive situation. As a result, management (at the author's company) has taken another look at the problem, and has decided to charge engineering with the responsibility for reliability and manufacturing with the responsibility for quality. The role of the reliability and quality groups is that of audit and surveillance, and they are part of the engineering and manufacturing organizations. This approach has proven to be an effective mechanism for achieving reliable equipment at a competitive cost. (Author in part)

REVIEW: This is a brief but thought-provoking paper on the role and organization of the reliability and quality groups in industry. The author is a manufacturing manager, which allows him to take the role of an "affected outsider looking in." In a private communication he has pointed out that although the paper draws on examples

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RELIABILITY ABSTRACTS
AND TECHNICAL REVIEWS

of mistakes in part and assembly fabrication processes as causes of equipment unreliability, this is not meant to imply that other causes do not also exist.

The statement that it is not uncommon to find a ratio of 1:1 between design and reliability personnel is subject to question. This may have occurred where a reliability group included a lot of the traditional engineering line functions, but much fewer personnel are normally used to perform the tasks required in a typical government reliability specification (see the paper covered by RATR 906). It should also be noted that relatively small reliability and quality groups which are competently staffed may satisfactorily perform surveillance roles without necessarily being part of the engineering and manufacturing departments. Aside from these points, the messages of this paper, that an anti-"reliability" ground swell is rising among traditional engineering and manufacturing personnel and that management is becoming increasingly aware that literal compliance with reliability specifications often results in a non-competitive position, are both worthy of serious consideration by reliability personnel. ##

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ASQC Codes 433;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Bayesian procedures and reliability information

AUTHOR: C. W. Hamilton (Battelle Memorial Institute)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 278-283 (*see RATR 2256)

PURPOSE: To describe the Bayesian statistical approach and to compare it with classical inference procedures in a reliability estimation context.

ABSTRACT: In the Bayesian approach to estimation the initial estimates of reliability can be derived from a combination of experimental data, theoretical considerations, and engineering judgment. As new data become available, the initial estimates are successively modified according to Bayes' formula to yield new (posterior) estimates of reliability. The estimates using this procedure are initially weighted by the prior information, permitting some realistic statement of confidence. This is contrary to the classical approach where effectively no statements of confidence can be made until considerable experimental data are collected. Several of the apparent advantages of the Bayesian approach are: (1) it appears to be well suited to reliability problems which typically involve limited data, (2) it is consistent with engineering practice, and (3) it gives a clearer interpretation of confidence. The basic mathematical framework for the Bayesian analysis is described. The general mathematical model is illustrated with an example concerning the estimation of reliability and the determination of confidence statements from life-test data assuming exponentially distributed failure times. (Author in part)

REVIEW: A strong case is presented here for the application of the Bayesian statistical approach to reliability and other engineering estimation problems. The reasons why this approach has not been used are not discussed. This is a readable paper on a basic aspect of reliability estimation which in all likelihood will receive increased attention in the near future. Valid means of using prior information will be especially helpful in the very common situation in which available data are quite limited. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The exact analysis of sequential life tests with particular application to AGREE plans

AUTHORS: Benjamin Epstein (Consultant, Palo Alto, Calif.) and A. A. Patterson and C. R. Qualls (Autonetics, Anaheim, Calif.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 284-311, 10 refs. (*see RATR 2256)

PURPOSE: To present methods for the exact analysis of any sequential life test under the assumption that the underlying distribution of times between failure is exponential.

ABSTRACT: AGREE life test plans are obtained by superimposing a truncated test on a Wald-type sequential life test so that a great deal of test time is not required to reach a decision. Exact analysis procedures for the properties of these tests were not available at the time the AGREE report was published. The result presented here is a method for computing exactly the properties of the life test plans recommended in AGREE. The discussion of exact analysis of general sequential life test plans includes computation methods for operating characteristic curves, for the distribution of the number of failures, and for the distribution of total test time. The procedure is recursive in nature and can be carried out easily with a high-speed computer. The methods which are developed are applied in the appendix to the analysis of the truncated sequential life test plans proposed by AGREE Task Groups 2 and 3. (Authors in part)

REVIEW: This is a statistical paper which presents nicely the further developments applicable to the analysis of AGREE-type life test plans. As the AGREE tests have received considerable discussion and some application, it is desirable that workers in reliability analysis be aware of these results. The means of studying the effects of truncation and of computing the properties of life test plans are important in the selection of the most suitable plan for a given application. Tables in the appendix comparing various characteristics of two AGREE test plans with equivalent truncated and sequential life test plans give good illustrations of the type of information which can be made available. ##

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10/65 63A16142 Serial Number 2270
ASQC Codes 221;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An approach to system reliability verification by test

AUTHORS: R. S. Pinkham* and L. N. St. James** (Bell Telephone Laboratories, Inc., *Murray Hill, N. J.; **Whippany, N. J.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 312-317 (*see RATR 2256)

PURPOSE: To indicate the inadequacy of Lot Tolerance Percent Defective sampling plans for system reliability testing, and to suggest an alternative approach.

ABSTRACT: The approach to system reliability testing which is finding its way into MIL specifications appears to borrow from the Lot Tolerance Percent Defective (LTPD) sampling structure originally developed more than 30 years ago. The usual system test proposals attempt to demonstrate at a high confidence that the actual reliability level of the system has been attained; seldom do they concern themselves with the probability of passing the test or minimizing the test cost. The limitations that this approach entails are discussed.

In order to establish a framework for the development of an alternative procedure, a series of assumptions are made. These include constancy of failure rates, independence of subsystems, known failure rates for component parts, and estimable subsystem failure rates. In addition to these it is assumed that:

1. On occasion the design group will produce a subsystem having a failure rate many times the estimated and acceptably low failure rate. That is, among the usual "good" subsystems there is an occasional "bad" one.

2. The probability of the design group producing a "bad subsystem" (one having a failure rate very much larger than the estimated failure rate) can be estimated from the past experience of a given design group.

A test procedure to discriminate between "good" and "bad" subsystems is proposed, and some of its properties are discussed. (Authors in part)

REVIEW: The points made regarding the inadequacy of LTPD sampling plans for system reliability testing are good. The proposed alternative procedure seems reasonable. As the authors have said, it has not been tested in practice, and undoubtedly many pitfalls can be anticipated. Much work remains to be done on the properties and limitations of the model, and this paper may stimulate further activity along these lines. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Avoiding shorted-coil failures

AUTHOR: James A. Foerster (Wabash Magnetics, Inc., Wabash, Ind.)

SOURCE: Electronic Design, vol. 13, 15 Feb 65, p. 54, 56, 57

PURPOSE: To point out that plastic flow is a wire-insulation failure mode and to show how to eliminate it.

ABSTRACT: Plastic flow of insulation can be a cause of coil failure if the hot spot temperatures are high enough. To try to avoid it by introducing another plastic (cement) with a lower operating temperature may actually be detrimental. The proper cure is to use an insulation with higher flow-point rating. The table shows several values (as determined in accordance with test procedure outlined in MIL-W-583B).

Plastic flow values

Wire Insulation	Recommended Min Flow-point Rating (^{o}C)
Overcoated polyester	225
Nylon-overcoated polyurethane	190
Polyurethane	190
Cement-coated Formvar	175
Formvar	175

REVIEW: This is a rather brief discussion of the problem of plastic flow of insulation. No mention is made of the relative frequency of this failure mode and whether its cures involve any tradeoffs with respect to other failures modes. Other papers on insulation failure have been covered by RATR 1749, 1752, 1755, 1859, 1860, 1926, and 2065. ##

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G

Serial Number 2272
ASQC Code 775

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: IR testing of microelectronics surges

AUTHOR: Ralph Dobriner

SOURCE: Electronic Design, vol. 13, 26 Apr 65, p. 6-9

PURPOSE: To describe the advantages of infrared testing of electronic devices.

ABSTRACT: Infrared (IR) is a very useful tool since it can be used to give a temperature photograph of a device. This temperature photograph is useful in design and also for nondestructive testing in quality checks. Its importance to reliability is great. So far it is used largely in laboratories rather than on production lines. Inertia of industry, the unknown aspects of its use, and high costs are reasons why so few are using it on production lines. The resolution and sensitivity are such that it is very useful in integrated circuits.

REVIEW: This is a newsy survey paper and neither treats any phase in detail nor gives any references. Within these limitations (which are probably intentional) the paper does serve a very useful purpose. Infrared testing, especially for integrated devices, may well become one of the most important design and quality check tools.

No mention is made of the variations in emitted IR with emissivity; this requires some sort of calibration for each circuit. (Figures 1 and 2 are interchanged and in the description of the correlation chart, the statement should be "... The resistance value ..." rather than "... The dc value ...")

For other references on the use of infrared techniques to enhance electronic reliability see RATR 626, 993, 1978, 1991, and 2126 through 2129. ##

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11/65 65N30311 Serial Number 2273
ASQC Codes 813;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Physics of failure in commercialand

AUTHOR: George H. Ebel (Fairchild Camera and Instrument Corporation, Du Mont Laboratories Division, Clifton, N. J.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 173-190 (*see RATR 2221)

PURPOSE: To discuss some aspects of commercial reliability.

ABSTRACT: The two outstanding differences between military and commercial reliability noted since reliability programs were instituted on our commercial products are (1) in the commercial field the emphasis on economic justification is greater, and (2) the spread in quality of components being sold to the same specifications is much greater for the commercial market. This paper discusses the interrelationship of these two aspects of commercial reliability. The greatest gains have resulted in reduced costs and improved reliability through "physics-of-failure" studies. The major reason for this is the misconception among people charged with the responsibility for selecting the parts used in an equipment that there is no difference between component piece parts that are purchased to the same specification. The goal of the commercial physics-of-failure program is to find the significant difference between parts which satisfy the basic specification, and to determine the optimum component for use in the particular application.

The techniques are applied to curative screening tests, vendor selection, and autopsies of failed components. The tools used for component analysis are discussed, showing how an effective laboratory was established at least cost. Particular emphasis is placed on radio noise analysis techniques. Not only have major reliability gains already been obtained using noise analysis, but the promise of future gains appears to be even greater.

Physics of failure is paying off in the commercial field. The best indication of this is that in the past year a larger fraction of reliability effort has been devoted to our commercial products than to military products. (Author in part)

REVIEW: Much of this paper is quite similar to parts of the one covered by RATR 1961. Otherwise, it is a useful explanation of the type of engineering analyses which need to be made to enable production of reliable products. ##

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65N30312

Serial Number 2274
ASQC Codes 813;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Physics of failure principles applied to a device development program

AUTHORS: T. C. Weston and J. L. Tomlinson (The Boeing Company, Aero-Space Div., Seattle, Wash.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 191-199 (*see RATR 2221)

PURPOSE: To describe a program to develop a special thin-film resistor.

ABSTRACT: This paper describes a program designed to develop and evaluate a high-ohms-per-square tantalum thin-film resistor. This program was undertaken primarily for the purpose of answering the two questions:

1. Could industry be expected to develop a satisfactory tantalum thin-film resistor for use in all vacuum-evaporated circuitry?
2. Are there techniques which can economically evaluate extremely reliable and long lived devices?

Based on the results to date, the answer to both these questions is a qualified "yes."

Assuming that the accelerated life test used in this program did indeed give a true acceleration, the best tantalum thin film resistors produced thus far have a predicted life of 500 years when operated at rated voltage. This would be roughly equivalent to a failure rate of less than .01%/1000 hours.

An accelerated life test can be used to evaluate new devices, but it should be used as a proof test rather than to determine the absolute life of the device. Accelerated tests will not soon replace the more conventional tests now being used, because of the difficulty in verifying a life of hundreds of years and the fact that a major portion of all part failures are of a mechanical nature, caused by manufacturing variability and inadequate design. However, accelerated tests can profitably be used to uncover basic defects in a device that could cause a failure within the relatively near term life (up to a few years). (Authors in part)

REVIEW: This appears to be a very reasonable program. It seems to use as much engineering information as possible, with assistance from formal statistics where feasible. ##

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Serial Number 2275
ASQC Codes 821;844;850

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Prediction of device reliability by mechanisms-of-failure principles

AUTHOR: G. E. Ingram (ARINC Research Corporation, Washington, D. C. 20006)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 200-209
(*see RATR 2221)

PURPOSE: To describe an approach to the assessment of the reliability of novel devices for space-age missions.

ABSTRACT: Construction of novel devices for space-age missions requires a new approach to the assessment of reliability of such devices and their components. The method suggested in this paper describes performance characteristics and failure mechanisms of a device in probabilistic terms. Environmental and stress conditions applicable to the device, and its performance and strength characteristics, can be expressed in the form of multidimensional probability distributions. By joint evaluation of these probability distributions, a quantitative estimate of the reliability of the device can be obtained. A limited example is given. (Author in part)

REVIEW: While the presentation is brief, it is adequate to explain the method. In a practical situation where high reliability is needed, the necessary probability information out on the tails of the distribution is generally not available. Thus the technique is more useful for finding gross defects in a design than for prediction. ##

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65N30314

Serial Number 2276
ASQC Codes 711;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A reliability predictor for semiconductor devices

AUTHOR: Martin F. Chamow (General Electric Company, Re-entry Systems Dept., Missile and Space Div., P. O. Box 8555, Philadelphia 1, Pa.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 210-237, 12 refs. (*see RATR 2221)

PURPOSE: To describe an exploration of the relationship of certain deviations observed in semiconductor devices to actual life-test performance, and the development and evaluation of a reliability predictor based upon this experience.

ABSTRACT: A prediction method for forecasting the operational longevity of semiconductor devices has been postulated and tested. It is based upon a concept of measuring and assigning quantitative importance to deviations from the behavior predicted by a simple model. Two independent groups of NPN silicon-junction transistors have been used to test the predictor, one of the groups being that from which the predictor was developed.

The methods reported in this paper were suggested by probability and statistical theory. All measurements were made purely for their physical content, however, the development was more physical than statistical. The two estimated parameters for each transistor were non-temperature-dependent leakage and thermal resistance of the collector. These were combined into a single estimator.

REVIEW: The paper is rather long and many of the statements are rather more enthusiastic than meaningful. The basic idea is good and the experiments seem to have been well carried out. The discussion of the theory suffers from non-exactness and being too long. ##

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11/65 65 N30315 Serial Number 2277
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure analysis techniques

AUTHOR: Wilton Workman (Texas Instruments, Inc., Dallas 22, Tex.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 238-263 (*see RATR 2221)

PURPOSE: To describe the failure analysis techniques at Texas Instruments, Inc.

ABSTRACT: The physics of failure effort must bring about a thorough understanding of the causes of device malfunction which then must be used to generate changes in the overall production and control techniques. Texas Instruments Failure Analysis Laboratory has developed a generalized routine for transistor failure analysis and is developing one for integrated microelectronic circuits. The resulting information is relayed to other responsible groups to attempt to prevent recurrence. Principal failure modes and analysis techniques are illustrated by charts and 'scope traces. (Author in part)

REVIEW: This is a well illustrated informative paper. The 'scope trace pictures are easy to read, but many of the half-tone photographs seem to be poorly reproduced. Even those who are experienced in the field will find the paper helpful for comparisons. ##

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ASQC Code 832

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Management of the human element in the physics of failure

AUTHOR: John F. Beau (Autonetics, A Division of North American Aviation, Inc.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 264-279 (*see RATR 2221)

PURPOSE: To describe methods for decreasing workmanship errors.

ABSTRACT: The methods used by the Navigation Systems Division of Autonetics to do a better job of managing the Human Element in the Physics of Failure are described. The relationship of escaping workmanship defects to field and in-house failures was established. Although it is acknowledged that perfection is a goal toward which Autonetics constantly strives, the fact remains that men, and to a lesser extent, test apparatus, do not do a perfect job every time. The system provided the following important elements:

1. Realization by each department that failure-causing workmanship-defect escapes can be controlled in a routine manner.
2. Allocation of a portion of the reliability budget to escaped workmanship defects; apportionment of the quality budget to the working level, so that workers know what they have to achieve.
3. Establishment of a standard for classifying defects in relationship to reliability requirements.
4. Use of Human Factors experts to provide assistance.
5. An audit system to measure the performance of inspectors against a practical standard.

No mention is made of management reports or corrective action systems because when a new individual comes upon the scene, he changes things to suit himself. Prompt feedback is provided to workers on the defects, and various courses of corrective action are followed. Heavy emphasis is placed on improving visual aids, work instructions and individual training. The program which has been described here experienced problems in its implementation which had to be overcome. (Author in part)

REVIEW: This paper is on a most important subject, although one which is generally relegated to Quality rather than Reliability. Many people are coming to realize that "foolish failures" are a prime cause of unreliability. It is interesting to compare this program with Zero Defects which is highly publicized. (To a large extent, this paper does not really deal with physics-of-failure as exemplified by most of the other papers at this conference.) ##

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11/65

65 N30317

Serial Number 2279
ASQC Codes 711;714;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Experimental confirmation of precipitation and oxidation in Evanohm condensate thin films

AUTHORS: David W. Levinson and Robert G. Stewart (IIT Research Institute, Chicago, Ill.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 281-305, 11 refs. (*see RATR 2221)

PURPOSE: To describe precipitation in and oxidation of thin films of Evanohm.

ABSTRACT: By electron and optical microscopic techniques, the precipitation out of the original solid solution of a phase based on Ni_3Al has been observed in the metal films which were condensed from Evanohm. As these films age a precipitation clustering of solute atoms causes a slight increase in the film resistivity. This is followed by a large decrease in resistivity as the solute content of the solvent or matrix is depleted by the growth of the solute-rich precipitates. The rate of these processes is faster for thinner films.

The oxidation of these films has been studied using electron microscopy to identify the reaction and a quartz-crystal microbalance to determine the reaction kinetics. Prior to precipitation, a uniform Cr_2O_3 oxide layer grows with a limiting thickness, saturating form of kinetics. This is typical of a case where a retarding electric field is created in the oxide layer by the migration of a charged species and eventually halts the diffusion or oxidation process. Later, after clustering and precipitation have occurred, a particulate oxide identified as NiO grows with kinetics proportional to the cube of time. This particulate oxide grows in the solute-depleted portion of the matrix. (Authors in part)

REVIEW: This is strictly a physics-of-failure paper. Its application is specific and direct. The work and reporting appear to have been capably carried out. ##

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11/65 65 N 30318 Serial Number 2280
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An investigation of thin film resistor failure

AUTHORS: P. C. Smith and M. Genser (General Precision, Inc., Kearfoot Div., Little Falls, N. J.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 306-314 (*see RATR 2221)

PURPOSE: To investigate the SiO darkening of some thin film resistors.

ABSTRACT: The important facts that these experiments reveal are

1. With a Corning 0211 glass, a degradation of SiO occurs only above 100°C and under an applied field. The degradation was observed only on the 0211 substrate in the times employed. None was observed on Corning 7059 and Alsimag #614 L624. Ionic migration may be the cause.
2. The degradation is apparently a temperature dependent rate process.
3. A vacuum baked substrate-resistor element will not show the effect unless it is exposed to the normal room ambient as opposed to pure oxygen. Water is hypothesized to be the villain.
4. The metal films are not attacked or affected directly. They may be affected when the SiO protective layer flakes off exposing the film. (Authors in part)

REVIEW: The paper discusses a worthwhile topic. As happens often in physics-of-failure, the results are of limited direct application, but are quite important there. Not all the reasoning is too good; e.g., the difference in response to normal ambient and to oxygen is asserted right off to be due to the water. It could be due to N_2, CO_2, or a host of other components of normal air. ##

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11/65 65 N 30369 Serial Number 2281
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Mechanisms of dc electrical breakdown in thin silicon oxide films

AUTHORS: N. Klein, H. Gafni and H. J. David (Israel Institute of Technology, Haifa, Israel)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 315-332, 15 refs. (*see RATR 2221)

PURPOSE: To report non-shorting breakdown events in silicon oxide dielectrics which are sandwiched between aluminum electrodes.

ABSTRACT: The electrical breakdown properties of thin silicon oxide layers covered with electrodes a few hundred angstroms thick differ considerably from those of thick insulations. Breakdown events are self-healing; they form single holes at lower fields and destroy larger regions at highest fields. At a constant voltage, breakdowns become less frequent as time goes by. They are promoted by increase in humidity and by a decrease of the external series resistance. Breakdown properties can be characterized by curves of capacitance change versus voltage. The dielectric strength is an inverse function of the dielectric thickness. Breakdown events develop by thermal instability, and destruction is caused by discharge of the capacitor or by energy supplied from the source. (Authors in part)

REVIEW: In this paper a series of observations of non-shorting breakdown behavior is given and interpreted to form an incomplete but certainly illuminating picture of the phenomenon. The presentation is rapid and meaty, and a large order to digest on initial exposure.

The subject matter is of considerable interest in contemporary microelectronics technology. While it is certainly not the final word that will be published on the subject, this paper fairly describes breakdown phenomena encountered in thin films. ##

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65N30321

Serial Number 2282
ASQC Codes 714;775;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Anion reaction for failure analysis of microcircuit components

AUTHOR: Edwin A. Corl (United Aircraft Corp., Norden Div., Norwalk, Conn.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 342-353 (*see RATR 2221)

PURPOSE: To illustrate an anion reaction method of detecting imperfections in silicon planar devices.

ABSTRACT An analytical technique for failure analyses on complex interconnected integrated circuits has been developed by employing the selective reaction of certain chemical components with metal interconnections. This technique has proven to be particularly useful in investigating failure due to the following:

a. Pinholes in metal-oxide-semiconductor capacitors
b. Poor or marginal contact of metal to silicon substrate
c. Pinholes or weaknesses in the oxide under metalized areas
d. Microscopic breaks in interconnections.

The experimental approach is based on the concept of reacting the interconnection metal with an anion which is attracted to electropositive regions and remains unreacted due to repulsion over electronegative metal regions.

Illustrations are presented herein consisting of anion reaction patterns on interconnected circuits showing the usefulness of this technique in the determination of poor or marginal capacitors, contacts and interconnections. (Author)

REVIEW: Even in black and white the illustrations of this paper are quite striking, the various shadings being reminiscent of the secondary electron photographs previously used to diagnose silicon circuit malfunctions (see RATR 1980). The technique described in this paper seems much simpler to implement. Unfortunately the composition of the solution used by the author is purposely omitted, presumably because this is the way the game is played.

No statement is made to indicate how destructive this technique is. Its role in device manufacture or failure analysis is not clearly evident from the description given.

Similar reactions could no doubt be observed using a gas ambient rather than the liquid solution hinted at here. ##

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11/65

65N23038
65N30580

Serial Number 2283
ASQC Codes 223;551;823

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Nonparametric life test sampling plans

AUTHORS: Richard E. Barlow and Shanti S. Gupta (Stanford University, Department of Statistics, Stanford, Calif.)

SOURCE: Technical Report No. 77, supported by the Army, Navy, Air Force and NASA under Contract Nonr-225(53) (NR-042-002) with the Office of Naval Research, Department of Statistics, Stanford University, Stanford, Calif., Jan 65, 72p, 11 refs. (~~AD-610 034~~; AD-613 273; NASA accession number N65-23038; AD-614 490 is same text, but does not include tables)

PURPOSE: To derive and tabulate truncated life test sampling plans which are valid under certain nonparametric assumptions.

ABSTRACT: Sampling plans for truncated life tests are developed under the nonparametric assumption that the lifetime distribution has either an increasing failure rate (IFR) or a decreasing failure rate (DFR). Properties of these distributions are reviewed. By using sharp bounds on such distributions, sampling plans are obtained which, although more conservative than the parametric plans, offer greater protection since they are valid for a much larger family of distributions. Let θ denote a parameter such as the mean, median, or other percentile. Usually one would like to establish that $\theta \geq \theta_o$ where θ_o is some specified value. In common practice a given number of samples are tested for a preassigned length of time t and the number of failures noted. If it is desired to establish a lower confidence bound on θ with confidence at least P and if the number of failures in the fixed time does not exceed a given number c, then the experimenter would like to know the minimum sample size to achieve this objective. Specific tables (52 pages) are given to obtain this minimum sample size when t, c, θ_o, P are preassigned.

Table I deals with the case in which θ is the mean and the life distribution is IFR. Tables II and III deal with θ as the q-th percentile, q = .1(.1).9, and the distribution is IFR or DFR, respectively. Use of the tables is illustrated by several examples. Some discussion of the producer's risk, consumer's risk, and the operating characteristic are presented along with approximations for the minimum sample size.

REVIEW: This report will be useful to engineers and statisticians concerned with life testing where the particular nonparametric assumptions made are more likely to be valid than the usual parametric assumptions. The references cited will provide additional details. Related papers, under parametric assumptions, have been covered by RATR 371 (normal and lognormal distributions) and RATR 157 (gamma distribution). Papers dealing with sampling plans based on the Weibull distribution were covered by RATR 46, 202, and 208. ##

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Serial Number 2284
ASQC Codes 421;822

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The Normal distribution and its limits of applicability

AUTHOR: Erich Pieruschka (Lockheed Aircraft Corp., Missiles and Space Div., Sunnyvale, Calif.)

SOURCE: LMSD480934, prepared under Bureau of Naval Weapons Contract NOrd 17017, Lockheed Missiles and Space Div., Sunnyvale, Calif., 15 Sep 60, 31p (AD-610 310)

PURPOSE: To describe some of the limitations in using the Normal distribution to describe physical phenomena.

ABSTRACT: This study is a probe into the application of the Normal distribution. It describes the limits of mathematical description of the distribution of a technical characteristic through the Normal distribution, including the fitting of a population distribution by transformation of a statistically distributed characteristic. Finally, there is a discussion of the necessary numbers of units to be tested in order to measure a low probability. (Author)

REVIEW: As the author has pointed out, reliability values of components, subassemblies and systems are often computed by fitting distributions of small samples through the Normal distribution. Thus this paper is directed toward an important problem. However, it can hardly be said to throw much light on the subject due to the abundance of misstatements of elementary statistical theory. For example, the central limit theorem is stated very loosely and then (supposedly) applied to the distribution of the sample mean $\bar{x}_n$ of a sequence of independent random variables, each being uniformly distributed on (0,1). The erroneous conclusion is drawn that $\bar{x}_n$ has a degenerate limiting Normal distribution with mean 1/2 and variance 0, whereas the central limit theorem tells us that the variable $(12n)^{1/2}(\bar{x}_n-1/2)$ has a limiting Normal distribution with mean 0 and variance 1. Similarly, in comparing tail probabilities of various non-Normal distributions with those of the Normal, ratios of such probabilities are used instead of (say) percentiles. The section on transformation considers only the logarithmic transformation, its only justification being that it leads to a positive random variable. Lastly, the concluding section on a nonparametric (?) method for determining the minimum sample size necessary to determine small probabilities is highly questionable and certainly not clearly stated. ##

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65 N 24055

Serial Number 2285
ASQC Codes 424;822;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Estimation in mixtures of Poisson and mixtures of exponential distributions

AUTHOR: A. Clifford Cohen, Jr. (Aero-Astrodynamics Laboratory, NASA, George C. Marshall Space Flight Center, Huntsville, Ala.)

SOURCE: NASA Technical Memorandum, NASA TM X-53245, Research performed by University of Georgia under Contract NAS8-11175 with NASA-MSFC, 19 Apr 65, 29 p (NASA accession number N65-24055)

PURPOSE: To derive parameter estimators for mixtures of Poisson and mixtures of exponential populations.

ABSTRACT: Estimators for the parameters of a mixture of Poisson distributions and of a mixture of exponential distributions are derived. The method of moments is used to give explicit estimates. Additional formulae are presented for the situations where some of the parameters are known a priori. For the Poisson case estimates are also obtained in terms of the sample zero-frequency count and the first two sample moments. An iterative procedure is described and a Fortran computer program given for calculating these estimates explicitly. Two numerical examples are given.

REVIEW: This paper gives the straightforward calculations necessary to derive parameter estimates by the method of moments. Most of the results given here have been obtained previously by P. R. Rider in Bull. de l'Institut International de Statistique 39(1962) p. 225-232 and Annals of Math. Statist. 32(1961) p. 143-147. The author gives credit to the first reference (listed erroneously as 38(1961)) but does not mention the Annals paper. The one seemingly new idea is that of basing the estimates on the sample zero-frequency count and the first two moments. Unfortunately this leads to transcendental equations which must be solved numerically. One numerical example of this method shows it to yield a better estimator than the method of moments. (The author in a private communication has indicated that the correct value of $\upsilon_{[2]} = 1.248$ was used in the calculations.) Whether the method always yields a better estimator than the method of moments is not known. No discussion of the properties of any of the estimators is given. ##

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65N27577

Serial Number 2286
ASQC Codes 822;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Two notes on estimating shape parameters

AUTHOR: Robert B. Wilson (The RAND Corporation, 1700 Main St., Santa Monica, Calif. 90406)

SOURCE: RAND Corporation Memorandum RM-4459-PR, prepared for USAF Project RAND, Apr 65, 16p, 11 refs. (AD-614 419)

PURPOSE: To derive new estimators for the shape parameters in the Weibull and gamma-type distributions.

ABSTRACT: In this memorandum, new estimators are derived for the shape parameters of a Weibull distribution and a gamma distribution. In each case a numerical table is presented to determine these estimators. The approach to reliability analysis taken here differs from the usual practice; instead of simultaneously estimating the various parameters of multi-parameter failure distributions, a marginal estimator is obtained for only one parameter of a two-parameter distribution. Bayesian methods, assuming the nuisance parameter to have the "natural conjugate" prior distribution, are used together with large-sample approximations. (Author in part)

REVIEW: This paper will no doubt be difficult for the practicing engineer or statistician not versed in Bayesian statistical theory to appreciate. The estimators obtained depend on asymptotic forms of the likelihood function and are thus somewhat limited in usefulness. However the estimators are fairly simple to calculate being given as solutions to certain transcendental equations. The tables given are of some help here, but are restricted by the choice of values given. The nicest property of the estimates is that they depend on the sample only through the arithmetic and geometric sample means. No other properties of the estimators are explored. It is not clear why in Table 2 (based on "large"-sample approximations) estimates are given for samples of size 2, 4, 8, 16, ..., etc. Also since $\alpha = a(1)$ is a random variable, results (2.7) and (2.9) should be corrected by omitting the symbol $\underset{n \to \infty}{\text{p lim}}$ and adding a term $o_p(1)$ to their right-hand sides. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Analyzing reliability data and designing acceptance tests

AUTHOR: Cynthia Kolb Whitney (Massachusetts Institute of Technology, Instrumentation Laboratory, Cambridge 39, Mass.)

SOURCE: E-1705, report prepared under DSR Project 52-225 sponsored by the Ballistic Systems Division, AFSC, Contract AF 04(694)-553, Massachusetts Institute of Technology, Instrumentation Laboratory, Cambridge 39, Mass., Oct 64, 45p (AD-610 850; NASA accession number N65-22030)

PURPOSE: To present some of the theory pertaining to confidence intervals in a reliability situation.

ABSTRACT: Persons designing testing programs to specify reliability functions and failure rates need theoretical means of assigning confidence intervals to the quantities obtained. Also, persons designing acceptance tests for items with unknown reliability functions need simple general methods of test design which do not rely on the myriad specialized tables for specific mathematical models available in the literature. The two problems are really opposite ways of looking at the same theoretical structure. The theoretical structure is examined and solutions to the problems are posed. (Author)

REVIEW: This paper suffers from the lack of clear definitions and assumptions. For example the definition of failure rate as "the probability per unit time that failure will occur at time t" is certainly rather obscure to even the most expert reader. The discussion of confidence intervals, one of the main considerations in the paper, is similarly unclear. Many of the derivations given in the appendices are erroneous as stated. Some of them can be easily "repaired" but it is doubtful that all of them can. ##

11/65

05N28846

Serial Number 2288
ASQC Codes 822;824

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

TITLE: Iterative techniques for estimating the parameters of the Weibull and gamma density functions

AUTHOR: George E. Hardy (Major, USAF)

SOURCE: Thesis presented to the Faculty of the School of Engineering of the Air Force Institute of Technology, Air University in partial fulfillment of the requirements for the degree of Master of Science, Aug 64, 64p (AD-610 769)

PURPOSE: To discuss and develop computer programs for evaluating maximum likelihood estimators of the parameters of the Weibull and gamma density functions.

ABSTRACT: This thesis develops computer programs which solve for the estimators of the Weibull and gamma density functions parameters through iterative techniques. The maximum likelihood estimators are developed and the iterative techniques used for each density function are explained. The operating instructions for the programs are included with explanations for eliminating errors that might develop within the programs. The estimators developed for a large number of samples are included. A comparison is made between the results of each program and the results achieved by another estimation technique. Finally, there is a short discussion concerning the distributions of the estimators. (Author)

REVIEW: This paper will be useful to the practicing engineer or statistician interested in obtaining maximum likelihood estimates for the densities discussed. However, the theory given is more completely presented in [1] (Chap. 7, sec. 5), to which the author refers. Hence the main value will be to those whose computing equipment can use the programs given directly (written for the IBM 1620 in symbolic machine language).

REFERENCE: [1] Reliability: Management, Methods, and Mathematics, David K. Lloyd and Myron Lipow, Prentice-Hall, Inc., 1962 ##

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11/65

64N22600

Serial Number 2289
ASQC Codes 551;822;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: On estimating location and scale parameters from truncated samples

AUTHOR: Lionel Weiss (Mathematics Research Center, U. S. Army, The University of Wisconsin, Madison, Wis.)

SOURCE: MRC Technical Summary Report #459, Contract DA-11-022-ORD-2059, Mathematics Research Center, U. S. Army, The University of Wisconsin, Madison, Wis., Mar 64, 13p, 5 refs. (AD-600 733; NASA accession number N64-22600) (published in Naval Research Logistics Quarterly, Vol. 11, No. 293)

PURPOSE: To obtain asymptotically efficient estimates of location and scale parameters based on truncated samples.

ABSTRACT: Asymptotically efficient estimators are developed for the problem of estimating a location and a scale parameter, using only the observations between the p th and q th sample quantiles. (Author)

REVIEW: In spite of the importance of the problem considered, this paper will be of little interest to all but the most theoretically inclined reader due to the unwieldiness of the formulae involved. The estimators obtained are linear in the observations but the coefficients are extremely complex. Not all of the (very detailed) mathematics in the paper was checked. ##

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Serial Number 2290
ASQC Codes 551;824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Statistical procedures for choosing the best one of several suppliers of a given product

AUTHOR: R. J. Griffith (Aerojet-General Corp., Avionics Div., Azusa, Calif.)

SOURCE: Reliability Department Technical Report No. 519-2-005, Aerojet-General Corp., Azusa, Calif., 28 Feb 61, 5p (AD-459 302)

PURPOSE: To describe two nonparametric methods for making comparisons among suppliers of a given item.

ABSTRACT: This report describes two nonparametric tests for determining which of several suppliers may be judged as the best one on the basis of comparative tests of a given item. The first procedure is applicable when two suppliers are being compared and the parameter of interest is a variable measurement such as length, pressure, etc. The second procedure can be used to compare two, three, four, or ten (this being limited to tabulated values) suppliers where the parameter is a binomial-type classification such as good or bad.

REVIEW: This expository report is based on a paper "On the sample size required for certain statistical problems in reliability studies" by M. Sobel and M. J. Huyett in the Proceedings of the Second Annual Statistical Engineering Symposium, Army Chemical Center, Maryland, April 1956. As such it presents nothing new but does very nicely explain exactly how to apply the results to practical problems. Two tables are given.

(In spite of the fact that this report is dated Feb 61, it was not entered into the DDC collection until Mar 65.) ##

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Serial Number 2291
ASQC Code 820

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Symbolic Boolean logic as applied to reliability engineering

AUTHORS: P. A. Hiltz and D. Amorelli (North American Aviation, Inc., Space and Information Systems Div.)

SOURCE: Publication 543-K, North American Aviation, Inc., Space and Information Systems Division, 16 Feb 63, 23p (AD-459 195)

PURPOSE: To show how symbolic logic may be applied to reliability engineering.

ABSTRACT: The basic concepts and rules of symbolic logic, propositional calculus, and the theory of sets are described. By way of example, it is shown that symbolic logic may be used to eliminate redundancy in the design of general systems of "black boxes." However, in reducing the system to its minimum configuration, it is shown that the system reliability will be reduced.

REVIEW: As far as symbolic/Boolean logic is concerned, it would seem that most readers would do better by consulting an elementary text such as Applied Boolean Algebra: An Elementary Introduction by F. E. Hohn (The Macmillan Company) or Symbolic Logic by I. M. Copi (The Macmillan Company). The examples given are of interest if one is clever enough to uncover the implicit assumptions made. ##

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11/65 64N19399 Serial Number 2292
ASQC Codes 824;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Upper bounds for the mean life of self-repairing systems

AUTHOR: Jaan Kruus (University of Illinois, Coordinated Science Laboratory, Urbana, Ill.)

SOURCE: Report R-172, Coordinated Science Laboratory, University of Illinois, Urbana, Ill., Contract DA-36-039-TR US AMC 02208(E), Jul 63, 34p, 22 refs. (AD-418 174; NASA accession number N64-19399)

PURPOSE: To investigate the effect of various subsystem parameters on system mean life.

ABSTRACT: Estimates for the mean life of a self-repairing system consisting of several identical machines, spare parts, and the necessary connecting and wiring mechanism are obtained by simulation. No detailed knowledge is assumed about the machines, except that each is by itself capable of performing the function required of the system, and that three of these machines may be interconnected to diagnose and direct the repair of a suspected fault in a fourth machine. The time required for diagnosis and repair is a random variable.

Failures are detected by observing the outputs of machines operating in parallel. A difference in outputs indicates a fault. A machine to be substituted for one which fails in operation must first be provided with the proper initial conditions in order that its output agree with that of other operating machines. This conditioning time may be a random variable. Spare machines are assumed to be subject to stresses of almost the same magnitude as those which are operating. To check the simulation results exact analysis is performed for a simplified system.

An improvement by a factor greater than 100 in system mean life over the mean life of an individual machine is attainable if the repair and conditioning times are of the order of 1/200 of the mean life of a machine and a sufficient supply of spare machines is available. The systems need about 20 machines for most efficient operation. System mean life is found to be quite sensitive to changes in the stress factor of spare machines. (Author in part)

REVIEW: This paper presents some results on improving system mean life using a particular self-repair type of design. As such it gives very useful answers about this specific design. The paper can certainly be recommended as general reading in this area, but whether or not generalizations from this work to other designs are possible is unclear. ##

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11/65

65N16553
65N23280

Serial Number 2293
ASQC Codes 824;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLES: The application of extreme-value theory to error probability estimation in the Ranger Block III Command Detector
Application of the statistical theory of extreme values to spacecraft receivers

AUTHORS: Edward C. Posner; John C. Ashlock and Edward C. Posner (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif.)

SOURCE: Technical Reports Nos. 32-705 and 32-737, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif., prepared under NASA Contract No. NAS 7-100, 15 Jan 65, 11p, 8 refs; 15 May 65, 9p (NASA accession numbers N65-16553 and N65-23280)

PURPOSE: To demonstrate the applicability of extreme-value theory to error probability estimation in certain types of receivers.

ABSTRACT: These reports present an application of statistical extreme-value theory to the estimation of low error probabilities in certain types of communications systems such as the Ranger Block III Command Detector. The systems considered all involve threshold detectors in a binary system. The estimation procedure which merely observes the occurrence of errors is too slow, whereas the procedure which attempts to find a theoretical distribution for amplitude deviations and then predicts error probabilities from the tails of this distribution is too unreliable. Extreme-value theory monitors not only the occurrence of errors but also how close the detection scheme comes to making errors even when no error is made. By taking the maxima of a large number of successive independent samples and then taking a large number of these maxima, the two parameters of the extreme-value distribution are estimated by the method of maximum likelihood. The large-sample variance of the error-probability estimate is found as well as the associated confidence bound. The proposed method is compared with the simple monitoring of errors method. Numerical results for the command receivers in Rangers VII, VIII, IX are given in the second report. (Authors in part)

REVIEW: The first of these reports proposes a useful approach to the problem of estimating very low probabilities. The technique is rather nonparametric in that it assumes only that the underlying distribution is of "exponential type on the right." The two crucial assumptions made are that the successive observations are independent and that the sub-sample sizes are large enough for asymptotic theory to apply. An actual numerical example is given to illustrate the method. The second report, which is essentially an extension of the first, gives much less theory but a large amount of experimental results. ##

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G

Serial Number 2294
ASQC Codes 814;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Probability of success and optimization models for parts reliability programs

AUTHOR: H. J. Hietala (Autonetics, A Division of North American Aviation, Inc., Anaheim, Calif. 92803)

SOURCE: Technical Memorandum 560-43-RSA-20, Autonetics, A Division of North American Aviation, Inc., Anaheim, Calif. 92803, 21 May 64, 48p (AD-459 720)

PURPOSE: To investigate certain aspects of system reliability in terms of the reliability of parts.

ABSTRACT: Two related problems are treated in this report. Given a system reliability requirement, how should reliability goals per part be chosen in order to achieve the system requirement at a minimum expense? Secondly, given a fixed system improvement cost, how should the money be allocated by part in order to achieve maximum system reliability? Solutions to these questions are obtained under certain fairly general assumptions. Procedures are also given for calculating the probability of success of the reliability improvement programs. Several applications together with numerical results are given.

REVIEW: This report will be of general interest to engineers and statisticians engaged in system reliability analysis. As usual, whether or not it will be directly applicable depends on the specific assumptions made. In particular all results are based on the assumption that the cost of a part is inversely proportional to its probability of failure in a fixed mission time. Much discussion is devoted to the calculation of the constant of proportionality in terms of other parameters. It seems that a considerable amount of "engineering judgment" will be required in this connection. The mathematics of the optimization is, as the author notes, quite simple; extensive use of the Lagrange multiplier method is made. ##

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65N21698

Serial Number 2295
ASQC Codes 775;821

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: A mathematical model to predict performance reliability of a manufactured component with multiple critical characteristics by nondestructive testing

AUTHOR: Eberhard H. Baur (Aerojet-General Corp., Sacramento, Calif.)

SOURCE: Report 9300-1S, Aerojet-General Corporation, Sacramento, Calif., 4 Nov 64, 14p (AD-609 964; NASA accession number N65-21698)

PURPOSE: To develop a model for the prediction of the reliability of a product based on assumptions about probabilities in manufacturing and quality control.

ABSTRACT: In this study, a mathematical model is developed for the estimation of the reliability of delivered items. The model is based on a series of assumptions about probabilities in manufacture and quality control. Quality control inspection is assumed to be of nondestructive type. The mathematical model also indicates the sensitivity of the reliability estimate with respect to changes of the probabilities in manufacture and quality control, and an optimization procedure for a reliability increase with respect to costs is outlined. Some considerations for establishing a confidence level for the reliability estimations are added. (Author)

REVIEW: This report rests entirely upon an equation (Eq. 2) which is derived in a section called "Mathematical Theory". The derivations given in this section are vague and not convincing, as many of the steps are presented without any justifying explanation. For example, on p. 11 no justification is given for using the geometric mean of the probabilities P_{qi} ($i = 1, 2, \ldots, k$) that quality control will discover the i th nonconforming characteristic. Hence the results of the paper are questionable, at best. Assuming that Eq. 2 is correct, the section on confidence levels is not necessarily true since lower limits on the independent variables do not always lead to a lower limit for the dependent variable. No proof is given that this is the case for the function considered here.
##

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11/65 65N24362 Serial Number 2296
ASQC Codes 822;823

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: An investigation of the burn-in and related problems

AUTHOR: Michael J. Lawrence (University of California, Berkeley, Operations Research Center)

SOURCE: Report ORC 64-32, Operations Research Center, Institute of Engineering Research, University of California-Berkeley, partially supported by the Office of Naval Research under Contract Nonr-3656(18), Nov 64, 28p, 15 refs. (AD-613 276; NASA accession number N65-24362)

PURPOSE: To present the results of an investigation of two problems involving the derivation of bounds on distributions with a decreasing failure rate.

ABSTRACT: Two problems involving the derivation of bounds on distributions with a decreasing failure rate (DFR distributions) are presented. Given that an item has a decreasing failure rate, sharp upper and lower bounds on the burn-in time to achieve a specified mean residual life are derived. The bounds rely on the DFR assumption and a percentile of the failure distribution.

An early estimate of the five year survival proportion (commonly called the five year cure rate) is of great interest in assessing the value of a treatment for a mortal disease such as cancer. Assuming that the distribution of time to death is DFR and assuming a knowledge of the mean and a percentile, sharp upper and lower bounds on the survival proportion are obtained. In addition some bounds on the hazard rate and density of a DFR distribution are given.

The time to burn-in to achieve a specified reliability has been determined in practice by assuming the life distribution is either Weibull or lognormal. This affords a very rapid and simple method for evaluating the burn-in time but in the majority of cases where these distributions are assumed, it is done with little statistical validation. A non-parametric approach based purely on the DFR assumption obviates this uncertainty of distribution validity and gives sharp bounds which, although more conservative, does guarantee achieving the specified reliability since it is valid for a larger class of distributions. (Author in part)

REVIEW: This paper is important to reliability theory through its contribution to the mathematics pertaining to the burn-in problem. The material is clearly presented and adequately referenced. The non-parametric approach has merit when there is not enough information to validate the assumption of a particular distribution.

Those concerned with the practical as well as the mathematical aspects of the burn-in problem should see also RATR 2211. ##

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11/65 65N18637 Serial Number 2297
ASQC Code 824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Use of experimental data in calculating the reliability of radio-electronic equipment, based on the Poisson distribution

AUTHOR: G. B. Linkovskiy

SOURCE: Russian Periodical, Izvestiya Vyschikh Uchebnykh Zavedeniy. Priborostroyeniye, Nr. 5, 1961, p. 43-46, Translation prepared by Translation Services Branch, Foreigh Technology Div., WP-AFB, O., FTD-TT-63-38/1+2, 18 Mar 63, 5p, 6 refs. (AD-402 426; NASA accession number N65-18637)

PURPOSE: To derive point estimates and confidence intervals for the parameter of the exponential distribution.

ABSTRACT: The maximum likelihood estimate of the parameter in the usual exponential expression for reliability is the mean time to failure. For a large sample, this estimate has a normal distribution and confidence intervals are easily assigned.

REVIEW: This is an unedited rough draft translation and reads accordingly. It contributes nothing new, since the results are in standard textbooks. The exact distribution of the estimate is also well known, so that the use of an asymptotic form is not necessary.
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Serial Number 2298
ASQC Code 800

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLES: 6 Efforts to extend the service-life of radio and television sets
Complaints about receivers made at the Chelyabinsk plant of the radiotechnical industry

AUTHORS: Yu Estrin (Minsk Radio Plant)
Vladimir Biyenko (Plant of the Radiotechnical Industry, Chelyabinsk)

SOURCE: USSR Industrial Development--Soviet Precision Equipment, No. 78, Translation prepared by U. S. Department of Commerce, Office of Technical Services, Joint Publications Research Service, Building T-30, Ohio Drive and Independence Avenue, S.W., Washington 25, D. C.; JPRS 19,721; 18 Jun 63; price $1.50 (AD-412 080), p.1-5, 24-26

65A23736

TITLE: The reliability of communications engineering hardware

AUTHOR: J. Katona, Budapest

SOURCE: Nachrichtentechnik, No. 2, 1962, p. 68-71, Translation prepared by Translation Services Branch, Foreign Technology Div., WP-AFB, O., FTD-TT-62-1820/1+2+4, 18 Feb 63, 14p (AD-299 667)

PURPOSE: Todescribe some of the problems associated with the reliability of electronic equipment in Russia and Hungary.

ABSTRACT: The reliability of radios and television sets tends to be poor. This condition is due to such causes as poor design, low-quality materials, faulty workmanship, and inadequate inspection. There is a lack of attention to detail and very often a poor attitude on the part of workers. There is a need for more adequate instrumentation for quality control and for better packaging of fragile items. However, progress is being made, and some plants are doing well.

Some of the problems encountered in the life testing of electronic components are outlined in the second report. Early failures, chance failures, and failures due to wear or aging are considered. The use of simple regression analysis to link failure rate with stress variables is outlined.

REVIEW: The first two papers are of a nontechnical nature, but they serve to show the reliability problems that other countries have. The causes of poor quality and low reliability are apparently ubiquitous and not confined by national boundaries.

While the second report contains some technical discussion, it is at an elementary level, and contributes nothing new for those familiar with the basic statistics applicable to the analysis of life-test data. ##

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11/65 65N11001 Serial Number 2299
ASQC Code 844

R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

TITLE: Sounding rocket reliability reassessment

AUTHOR: Abrom Hisler (Goddard Space Flight Center, Greenbelt, Md.)

SOURCE: NASA Technical Note NASA TN D-2222, National Aeronautics and Space Administration, Washington, D. C., Nov 64, 22p, 38 refs. (OTS $0.75)

PURPOSE: To discuss an approach for reassessing the reliability of a given solid propellant propulsion system for a sounding rocket.

ABSTRACT: Reputedly reliable sounding rocket propulsion systems have occasionally experienced motor failures with the attendant waste of time, effort, and money. In an attempt to uncover the causes of motor failure it is important to focus attention on all modes of possible failure. The basic problem may be stated, "Where and how have modes of failure crept into a rocket motor because of quality control breakdowns, or during new conditions of operation?" From the failure data gathered in the field it is possible to arrange the possible modes of failure as they may creep into the life cycle of the motor. Presented in this report is an approach which culls past rocket failure data for an organized failure-modes attack on rocket motor malfunctions. Appendix A discusses the thinning grain structure collapse theory, where a premature collapse of the grain structure results in a blow because of the unusually large amount of exposed propellant surface area inside the operating chamber. A troubleshooting worksheet is included as Appendix B to demonstrate the manner in which a necessary sequence of events can be used as a frame of reference to run down the modes of failure responsible for a particular motor failure. A checklist of all known failure modes should be prepared and updated; Appendix C is a start in this direction. Appendix D is a failures study chart which presents a fast rundown on a particular failure, the assumed modes, and the corrective action taken, with consequences. (Author in part)

REVIEW: The more specific results are mainly in the appendices, and the body of the report is background discussion of the general approach. There are no equations or numbers in the entire report. The appendices would be of interest to those concerned with the design and reliability of solid propellant rocket motors, and of course in particular those persons concerned with a failure mode and effect study. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Economic decision criteria for repair versus throwaway maintenance

AUTHOR: O. E. Davis (Vitro Laboratories, Silver Spring Laboratory, 14000 Georgia Avenue, Silver Spring, Md.)

SOURCE: Technical Report Number 01816.01-3 prepared for Department of the Navy BUSHIPS under Contract NObsr 89362 by Vitro Laboratories, Silver Spring Laboratory, 14000 Georgia Avenue, Silver Spring, Md., 29 Sept 64, 70p, 31 refs. (AD-455 102)

PURPOSE: To present the results of a study to (1) aid the designer in minimizing the total lifetime cost of an equipment and (2) provide criteria for designating shipboard repair, depot repair, or throwaway for an existing module.

ABSTRACT: This report summarizes the results of 14 months of study concerned with the economic feasibility of throwing away modularized electronic assemblies instead of repairing them. Several cost equations in varying degrees of complexity are developed. The most complex are cumbersome to use, although inherently the most accurate and versatile. The four major equations are total life cost of (1) a repairable assembly and (2) a throwaway assembly, and cost differences on (3) a complex basis or (4) a limited basis. The limited cost difference model allows the designer to determine quickly an economic comparison of the throwaway or repair procedure. Graphs are presented for decision aids. The basic assumptions which were made are presented. Values are given for some of the model terms, sources are suggested for others, and some are to be developed by the model user. The models were applied to two equipments, the AN/SRC-16 communications central and the AN/SSQ-29 data terminal, for a feasibility test. Results indicated that 47 of 138 modules could be economically thrown away. The models should provide reasonably accurate decisions, limited mainly by the accuracy of the term values. Some general results are that modules costing less than $120 should be discarded and that the decision is independent of module population or failure rate.

REVIEW: The results presented here are useful for practical application. In a study of this type there must always be reasonable decisions to omit additional considerations. Assumptions which were made are spelled out and a user can judge their validity for his particular application. For example, the criterion used here was cost, but it would seem that equipment up-time would also be affected. Restoring a failed equipment with module level replacement should be faster than doing so at the part level. This is a worthwhile addition to the growing references in the maintainability and related costs area. ##

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63 N15104

Serial Number 2301
ASQC Codes 782;835;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Investigations of fundamental limitations determining the ultimate size of microstructures

AUTHOR: J. T. Wallmark (Radio Corporation of America, RCA Laboratories, Princeton, N. J.)

SOURCE: AFCRL-63-12, Special Scientific Report No. 2 prepared for Electronics Research Directorate, Air Force Cambridge Research Laboratories, Office of Aerospace Research, USAF, Bedford, Mass., under Contract No. AF19(604)-8040, 31 Dec 62, 19p, 9 refs. (AD-402 115; NASA accession number N63-15104)

PURPOSE: To report the results of research on the minimum size and maximum packing density for solid-state devices.

ABSTRACT: In an earlier report (see RATR 391) it was shown on the basis of various physical phenomena that a minimum size and a maximum packing density exist for semiconductor devices. This report similarly treats solid-state devices in general; i.e., active devices, such as magnetic, superconductive and dielectric devices, as well as passive devices, such as resistors and capacitors. Solid-state devices are limited to a minimum size of about 3 microns on a side. In a circuit, the minimum space per component is about 6 microns on a side corresponding to a maximum packing density of about 5×10^9 components/cm^3. The assumptions used in the analysis were:

Devices of cubic shape (arbitrary shape allowed subsequently)
The system contains 10^5 identical devices with no redundancy
No negative feedback in circuits or fabrication
No shrinkage caused by accidents in fabrication
Ideal material and no surface effects
Allowed tolerances $\pm$ 10%
Equal and independent deviations in device parameters.

The chief limiting physical phenomenon is the edge definition in fabrication of devices. For superconductive devices the cooling equipment is a major limiting factor to high packing density. While this limiting size of a component is within reach of existing fabrication methods, economic considerations will undoubtedly set a practical size exceeding the minimum size for the foreseeable future. (Author in part)

REVIEW: This is a good analysis within the limitations of the assumptions. Factors such as cosmic rays, considered in the earlier report (see RATR 391), are omitted in this one. The comments on the earlier paper apply also to this one. This type of work is quite profitable since it helps to give perspective to present trends and goals. ##

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11/65 65N84227 Serial Number 2302
ASQC Codes 813;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Design techniques for long term reliability of aerospace electronic communication equipment

AUTHOR: --

SOURCE: Technical Documentary Report No. AL-TDR-64-1, Avionics Laboratory, Research and Technology Division, Wright-Patterson AFB, O., prepared under Contract No. AF33(657)-9147 by The Bendix Corporation, Bendix Radio Division, Baltimore, Md., 21204, Dec 63, 228p, 27 refs. (AD-429 882)

PURPOSE: To report comprehensively on the first 16 months of work on a program to develop design techniques upon which will be based future aerospace communications equipment with long-term reliability.

ABSTRACT: This program involved an extensive amount of experimentation in addition to literature searches and theoretical analyses. A completely solid-state transceiver was designed, and was built in breadboard form. The receiver is a dual-conversion superheterodyne, and the transmitter contains a power generator, a phase modulator, and a cascaded varactor frequency multiplier. Some general reliability considerations are presented, i.e., infant mortality, effects of aerospace environments on parts, and reasons for stress derating. Results are presented on investigations to determine thin-film component reliability and failure mechanisms. It is concluded that the most important mechanisms are dependent on the temperature. A reliability model is developed for the transceiver, and a prediction is made. Indications are that with proper application and derating of components together with judicious application of redundancy techniques it is possible to develop a highly reliable solid-state transceiver in the gigacycle range while providing a reasonable efficiency of operation and performance. The primary limiting factor in approaching the performance goals are the efficiencies and power capabilities of available varactor diodes and higher frequency power transistors.

REVIEW: Most of this report is devoted to a performance-oriented functional description of the transceiver, with a small portion of the total report on reliability. The reliability section is largely an introductory-level discussion. It ties in somewhat with the functional descriptions, but the latter are almost explicitly independent of the material presented in the reliability section, except for reflecting the usage of generic part types recommended there. Reliability tests to detect failure mechanisms are briefly cited in several places, but no details of them are presented. These aspects of the report probably are a reflection of the typical difficulties of actually applying reliability principles in a normal design and development effort. ##

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66 X84122

Serial Number 2303
ASQC Codes 814;825;831;
872;882

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability cost/effectiveness: A pilot study
Final Report

AUTHOR: S. H. Brooks (Aerospace Corporation, San Bernardino Operations, Computation and Mathematics Center, San Bernardino, Calif.)

SOURCE: Report No. TDR-269(S4853)-1, prepared for Headquarters, Ballistic Systems Division, Air Force Systems Command, Norton Air Force Base, Calif., Contract No. AF04(695)-269, AF04(695)-469, by Aerospace Corporation, San Bernardino, Calif., Jun 64, 41p, 89 refs. (AD-451 906L; NASA accession number ~~N65-12582)~~

PURPOSE: To present the results of a pilot study on a cost/effectiveness (C/E) approach to reliability and associated system parameters of missiles.

ABSTRACT: Total system cost is expressed in terms of the nonrecurring and recurring costs, which in turn are each expressed in terms of the cost of those activities which have an appreciable effectiveness impact and those which do not. Listings and definitions are presented of the related nonrecurring and recurring activities. Effectiveness is assumed to be proportional to the number of reliable missiles. A general relationship between reliability and cost is obtained by assuming that the rate of improvement of reliability is proportional to the remaining unreliability. A C/E model is then obtained by gathering together these relationships. It is then possible to optimize C/E by finding out how much should be apportioned to the reliability costs. Some parameter values are established and sample calculations are made. Requisite optimization methods are discussed. Information needed for a C/E analysis is only obtainable by an extensive examination of Air Force and contractor records. Preliminary indications are that C/E modeling is feasible and leads to methods of program control. Work tasks for further studies to expand these results are presented.

REVIEW: As noted in the report, the C/E model developed here is somewhat different from those typically presented in the literature. The model is extremely simplified, explicitly omitting maintenance, availability, and performance capability; it is based on assumed fundamental relationships. These results are from a pilot study and presumably such questions as the validity of the assumed fundamental relationships, the consequences of omitted characteristics, and the establishment of realistic parameters would be resolved prior to attempts at real applications. RATR 2200 covers an extensive study of essentially the same subject. ##

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Serial Number 2304
ASQC Codes 802;813;830;
844;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Bureau of Naval Weapons Reliability Engineering Handbook (Proposed NAVWEPS 00-65-502)

AUTHORS: --

SOURCE: Prepared for Engineering Division (RREN), The Bureau of Naval Weapons, Department of the Navy under Contract N600 (19) 59969 by Bird Engineering-Research Associates, Inc., P. O. Box 126, Vienna, Va., 1 Jun 64, 325p

PURPOSE: To provide for the Bureau of Naval Weapons: (1) reliability program implementation guidance, (2) demonstration of the procedures used, and (3) technical detail sufficient for design guidance.

ABSTRACT: Pertinent reliability documents are described and their applicability at different points in the life cycle is shown. Procedures are described for the analyses to be made during the planning phase in order to generate the essential descriptive information for the preparation of technical development plans, design specifications, requests for proposals, and contractual task statements. Included are the definition of operational requirements, the estimation of achieving these requirements, and the allocation of requirements. The essential reliability program activities deemed vital to development programs are set forth, emphasizing planning, monitoring and review. Step by step procedures are given for the definition and documentation of reliability and maintainability requirements in essential planning documents, specifications, and contractual task statements. Procedures are described for predicting reliability based on MIL-STD-756A and MIL-HDBK-217. Concepts of development, qualification, and acceptance testing are discussed; procedures are presented for the design and implementation of these tests. Other topics included are the failure analysis and feedback loop, reliability-cost-time relationships, and new considerations of design and planning. Appendices include definitions, basic reliability modeling, reliability estimation, and redundancy considerations in design.

REVIEW: This is an addition to the growing family of government-sponsored reliability manuals and handbooks. It has a good sense of completeness over a program's time phases from the viewpoints of both a procuring governmental agency and a contractor. The technical material is conventional state of the art and somewhat limited. Warnings are often given when the validity of the method presented may be subject to question or limitation. Few references are cited, and most are government specifications and standards. This handbook would be helpful to those dealing with the Bureau of Naval Weapons and to newcomers to reliability. ##

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11/65 65 N 20568 Serial Number 2305
ASQC Code 871

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE Planned replacement

AUTHORS: Chauncey F. Bell and Milton Kamins (The RAND Corporation, Santa Monica, Calif.)

SOURCE: P-3052, The RAND Corporation, Santa Monica, Calif., Jan 65, 9p (AD-610 285; NASA accession number N65-20568)

PURPOSE: To present a brief description of a continuing research effort on planned replacement policies which was started after it seemed that routine misapplications were occurring in both military and commercial aviation.

ABSTRACT: The major purposes of a policy of planned replacement are increased safety, improved reliability, and, where possible, greater economy. If planned replacement is to be worthwhile there must be an increasing failure rate (wearout) with time or use, and a penalty for failure in service. If either of these conditions is absent, planned replacement is not desirable under any conditions, even safety of flight. Further, even when both are present planned replacement may not be worthwhile. A technique has been developed for finding where planned replacement is worthwhile by taking the added penalty costs for unexpected failure into consideration. As an illustration, the actual failure rate of a hot-gas generator shows an infant mortality of 600 flying hours, 800 hours of unchanging failure rate, and 600 hours of increasing failure rate. It is currently fashionable to use the estimated mean life as the mandatory replacement time, which for this generator would result in replacement at 700 hours or just when entering the most reliable period. Analysis of failure data has indicated that many other components do not show wearout, often where informed people were sure wearout would be present. Applications of these concepts by a commercial airline reduced the schedule for nine successive Boeing 720 overhauls from an original removal of 1200 components to 33. And yet the irregular removal rate is down also. (Authors in part)

REVIEW: The examples cited which are based on a review of empirical data for aircraft are startling. It is also possible that unnecessary and harmful replacements are occurring on a widespread basis for other systems such as those used in land and sea transportation. This paper illustrates the great value of proper analysis of empirical reliability and related data, as well as the large gap which exists between known theoretical concepts and the proper widespread application of even the elementary concepts. The paper itself is brief, but a reference apparently contains more detail.
##

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11/65

Serial Number 2306
ASQC Code 813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability program implementation

AUTHOR: --

SOURCE: Report No. 2869, Aerojet-General Corporation, Azusa, Calif., May 64, 23p (AD-459 300)

PURPOSE: To describe the functions of the reliability program at the Production Projects Division of the Aerojet-General Corporation.

ABSTRACT: The Reliability Department is responsible for both the reliability functions and the development of the needed technical and engineering capability. The reliability program assures that high levels of reliability will be designed into the system, verified by a sound test program, maintained throughout manufacture, transportation, storage and launch, and improved through a closed-loop feedback system. It includes the surveillance and integration of the programs of associated contractors, subcontractors, and suppliers. A reliability program plan relates the internal program to specific equipment being developed; associated cost analyses are prepared. Other elements of the program administration include controls, documentation, PERT, and training. Statistical and mathematical reliability activities include apportionment, a prediction model, an assessment model, failure mode and effect analysis, requirements study, and environmental design criteria. The reliability design review is the control applied to assure that the design will meet the specified functional and reliability goals. Reliability assists in planning an adequate test program, and then audits it. A reliability data processing system provides the customer, other functional organizations, and management with significant information upon which reliability decisions can be formulated.

REVIEW: A typical reliability program of a government contractor is presented here. The scope is broad and it is difficult to say what may have been omitted without also seeing the functions of the entire organization. The real criterion for judging a program is the detailed manner in which it is assimilated into the total organization, which is only hinted at in written procedures. Most government contractors already have incorporated this type of documentation into their functions and procedures manuals, or they are now doing so. ##

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Serial Number 2307
ASQC Codes 813;815;831;
870;880

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Concepts associated with system effectiveness

AUTHOR: --

SOURCE: Bureau of Naval Weapons, Department of the Navy, Washington 25, D. C., June 63, 83p (AD-460 706) but see 67X83587

PURPOSE: To identify the basic elements of system effectiveness (SE), explore their interrelationships, and present some of the mathematical theory useful in the associated measurement and prediction problems.

ABSTRACT: Care has been devoted to the selection and definition of terms; they are chosen in accordance with accepted usage and to permit discrimination between concepts. SE is defined as the probability that the system can successfully meet an operational demand within a given time when operated under specified conditions. Thus SE is influenced by the way the equipment was designed, built, used, and maintained. Many related terms are carefully defined and discussed, such as types of times (operating, down, etc.), reliability, availability, operational readiness, and repairability. Interrelationships among the properties associated with these terms are then discussed, with emphasis on the relationships among time intervals. Implications of the application of mathematical analysis to the concepts are cited, with an effort to limit the use of mathematics. Reliability prediction techniques are reasonably well developed, but in optimizing SE it is also necessary to be able to predict the difficulties that will be encountered once an equipment has failed. Techniques for predicting repair times are proposed, and a numerical illustration is given.

REVIEW: This is a readable essay on the concepts which bridge the gap between the real world's occurrences and mathematical models. It is (by intention) more maintainability than reliability, and does not dwell much on cost. The ending is rather abrupt and no final conclusions are drawn; also, no references are cited. Thus it is best suited for someone already familiar with the subject and who is seeking further insight into the basic notions. A comprehensive recent effort in the SE area is covered by RATR 2200, which apparently used many of the notions cited here. ##

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11/65 63N19329 Serial Number 2308
ASQC Codes 711;714;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure mechanisms in ferroelectric and nonlinear dielectrics

AUTHORS: H. H. Barrett, P. B. Nutter, A. Paladino, and J. S. Waugh (Raytheon Company, Research Division, Waltham 54, Mass.)

SOURCE: RADC-TDR-63-238, prepared for Rome Air Development Center, Research and Technology Division, Air Force Systems Command, USAF, Griffiss AFB, N. Y. under Contract No. AF30(602)-2678 by Research Division, Raytheon Company, Waltham 54, Mass., May 64, 76p, 48 refs. (AD-605 795; OTS $3.00)

PURPOSE: To determine the fundamental behavior at high fields of strontium titanate.

ABSTRACT: Breakdown fields in single-crystal $SrTiO_3$ have been measured over a temperature range of $-195^{o}C$ to $100^{o}C$ and the results are compared with the predictions of Frohlich's theory. Measurements are consistent with the theory on magnitude and temperature dependence of breakdown field except at the lower temperatures where the disturbing effects of electrostrictive strain are considerable. A marked variation of dielectric and resistive properties of $SrTiO_3$ samples is observed to be dependent upon the sample's history and a qualitative explanation of the effect is proposed.

Bulk diffusion constants in annealed and unannealed $SrTiO_3$ have been measured directly. The diffusivity is found to be dependent upon dislocation density but is several orders of magnitude too low to explain the rapid oxidation rates observed in $SrTiO_3$. Alternative explanations of this discrepancy are put forward. (Authors)

REVIEW: This type of work will contribute to high reliability even though it is rather specialized. Reduction of scatter in addition to raising of strength should be an important goal of physics-of-failure studies because it has a direct bearing on reliability.
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64N22278

Serial Number 2309
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Detailed study of deleterious effects on silicon transistors

AUTHORS: Motorola Inc., Semiconductor Products Div., 5005 East McDowell Road, Phoenix, Ariz.

SOURCE: RADC-TDR-64-111, prepared for Reliability Branch, Rome Air Development Center, Research and Technology Division, AFSC, Griffiss AFB, N. Y. under Contract No. AF30(602)-3244 by Motorola Inc., Semiconductor Products Div., 5005 East McDowell Road, Phoenix, Ariz., Apr 64, 41p (AD-600 875)

PURPOSE: To describe and interpret some surface effects which harm silicon planar devices.

ABSTRACT: Surface effects cause (1) degradation of beta in planar bipolar transistors, (2) high reverse current and low breakdown voltage in planar p-n junctions, and (3) unstable source-drain characteristics of MOS transistors. Important variables include: (1) ambient during baking cycle at 300°C, (2) operating bias, (3) external electric fields normal to the surface, and (4) processing techniques, particularly the introduction of chemical residues. Three possible models are: (1) charge separation on the oxide surface, (2) the creation of donor states at the oxide-silicon interface by the oxidation process, and (3) charge motion in the oxide under applied bias and temperature.

REVIEW: This report is another qualitative discussion of surface problems in silicon device technology. It is a sequel to the paper covered by RATR 1415, and discusses more than the surface charge separation model, although the introductions of the two papers are identical.

This report's primary value is the empirical data presented on various devices, e.g., the observed variations of (1) junction breakdown voltage with reverse current, and (2) transistor beta with voltage applied on a surface electrode. The reader looking for new insight into the surface problem is likely to be disappointed.

The brief applications section seems largely a repeat of previously published ideas to which nothing new has been added. Communication is hampered by the frequent appearance of ambiguous statements such as "When the concentration of surface induced charges is high enough to compensate original bulk depletion layer is altered and consequently the field configuration is modified," or "With this state, if the device is heat treated at 200 to 300°C, the surface condition changes the mobility of the charges on the surface by reacting with the surface or with the ambient." ##

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64N15074
65N12968

Serial Number 2310
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Study of comprehensive failure mechanism theory
Study of comprehensive failure theory

AUTHORS: M. E. Goldberg, A. Horberg, H. A. Lauffenburger, D. W. Levinson, and R. G. Stewart (IIT Research Institute, Chicago, Ill.)

SOURCE: RADC-TDR-63-431 and RADC-TDR-64-309, prepared for Rome Air Development Center, Research and Technology Division, AFSC, Griffiss AFB, N. Y. under Contract Nos. AF30(602)-2731 and AF30(602)-3054 by IIT Research Institute, Chicago, Ill., Aug 63, Sep 64, 69p, 17 refs., 195p, 81 refs. (AD-426 733, AD-608 365; NASA accession numbers N64-15074, N65-12968)

PURPOSE: To analyze the behavior of a thin film resistor and a silicon planar diode.

ABSTRACT: Precipitation and oxidation are two principal failure mechanisms occurring in deposited metal film resistors. Uncased resistors aged in the absence of oxygen show the behavior expected of the precipitation process: reduction of resistance with time. Evidence of clustering is also obtained. Uncased resistors exposed to oxygen at high temperature show the anticipated increase in resistance with time, i.e., a fourth power relationship for the oxidation kinetics. A mathematical model of resistor behavior, involving oxidation and precipitation, has been investigated and programmed for the IBM 7090 computer. Certain of the necessary coefficients are estimated from Minuteman reliability test data, from the literature, and from our experiments. The resulting computations agree poorly with available resistor test data. This is attributed to (1) unmodeled mechanisms, and (2) the data available for validation studies do not detail the film thickness which is an important parameter in the model.

A silicon planar epitaxial diode has been selected as the semiconductor device to model. Studies of failure mechanisms point to ionic contaminant migration as the probable first order failure mechanism. (Authors in part)

REVIEW: The titles for the reports are much more ambitious than the actual work. Similar and related work by the same group has been reported in the papers covered by RATR 1409, 1698, and 2279. The hopes for the success of a comprehensive failure theory must be long-range. In the two years of this project, the progress is such that a few decades, rather than a few years, would be the time scale for solving the problems. The work itself appears to be thorough and well founded. The semiconductor research is largely limited so far to review of present knowledge. (Much of the material in the second report is found also in the first.)

##

11/65 65N14015

Serial Number 2311
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Study of part failure modes

AUTHOR: Lester J. Gubbins (Rome Air Development Center, Research and Technology Div., Reliability Branch, AFSC, Griffiss AFB, N. Y.)

SOURCE: Technical Documentary Report No. RADC-TDR-64-377, Reliability Branch, Rome Air Development Center, Research and Technology Division, AFSC, Griffiss AFB, N. Y., Oct 64, 79p (AD-609 056)

PURPOSE: To present data on relative occurrence of various failure modes in electronic parts.

ABSTRACT: Data are presented which show the relative frequency of occurrence of the various failure modes of parts based on field data collected from certain ground electronic equipments and on individual parts tests. The data are compiled on 30 subcategories of parts, the major categories being capacitors, resistors, inductive devices, transistors, diodes, tubes, relays, switches and connectors. Two examples involving series and parallel connections are given showing how to use the data in making decisions involved with the use of a multiplicity of parts to compensate for some failure modes. A discussion of categorizing failure modes is included. (Author in part)

REVIEW: This type of information is certainly needed. Unfortunately the information in this report is rather incomplete. In most cases it is not suitable for more than qualitative estimates. The first example is rather poor and the treatment is not the best. In fact, as pointed out in the text elsewhere, the data are not complete enough for a good treatment.

When redundant parts are used, a very carful analysis should always be made to assure that the circuit will actually work in the conditions for which it is presumed to work. For example, the voltage drop across two diodes in series may cause the circuit to function poorly. In the logical analysis, one must always distinguish between a logic diagram and the circuit diagram. ##

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Serial Number 2312 -1
ASQC Code 870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

63A16144

TITLE: Requirements for Air Force weapon system maintainability

AUTHOR: Lt. Colonel Edward R. Fallon, Jr. (Headquarters, United States Air Force, Aircraft & Missiles Div.)

63A16145
63N15664

TITLE: Derivation of maintainability requirements

AUTHOR: T. B. Slattery (General Electric Company, TEMPO, Santa Barbara, Calif.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 326-331; p. 332-338, 6 refs. (*see RATR 2256) (NASA accession number N63-15864 pertains to the second paper)

PURPOSE: To discuss the need for improved maintainability and the actions taken by the Air Force to achieve it; to present an approach to the derivation of maintainability requirements.

ABSTRACT: Lack of a standard definition of maintainability has led to confusion as to what is generally meant when a maintainability requirement is included in a contract. DoD is making a concerted effort to prepare and publish a standard list of maintainability terms and definitions. The largest single function in the Air Force is maintenance, accounting for about one-third of the total budget. Personnel, facilities, supply items and system modifications are each cited for their contribution to high maintenance and costs. Lives lost and missions that have failed are far worse than money costs. The Air Force has launched a maintainability program leading to official documents, including a regulation, standard, specification, and management guide. Quantitative system maintainability requirements will be specified in requests for proposal and work statements.

In the past, maintainability requirements were generally called out on a best effort basis if they were mentioned at all. Action by DoD culminated in a number of maintainability specifications, which are cited. Maintainability requirements must be considered in the framework of a total weapons system operational availability. The total length of time that a system is down results from a number of elements such as failure detection, diagnosis, correction, and checking. Insufficient data and knowledge exist on most systems to determine the contribution to downtime of these elements. Requirements are meaningless to the design engineer unless there are predictive methods available to assist in designing to meet them. The design engineer cannot be held responsible for the design time elements that pertain to field operation, i.e.,

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logistics, waiting times, and technician capabilities. Maintainability requirements have evolved rapidly; there is a serious danger that over-specification of details and data requirements will actually restrict the contractor. The contractor should be required to meet broad systems requirements, should be given maximum flexibility in doing so, and should be held rigidly accountable for his final performance.

REVIEW: The high maintenance costs discussed in the first paper are a convincing argument that maintenance improvements are needed, just as reliability improvements are needed. This is a "pep talk" type of paper, saying in part "...maintainability has arrived and the Air Force expects industry to produce results." Experience with reliability has shown that it is one thing to include an "ability" specification, and yet another to implement it so as to obtain results worth the money spent.

The second paper identifies some of the many problems in the implementation of an explicit maintainability program. These problems fall heavily on both the government procuring agency and the contractor. The author of this paper is also co-author of an early book on systems maintainability [1].

REFERENCE: [1] Goldman, A. S. and Slattery, T. B., Maintainability: A Major Element of System Effectiveness Wiley, 1964 ##

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ASQC Codes 871;873;875

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

63A16146
I. TITLE: Maintainability program during the design stage

AUTHOR: W. Robert Gibson (Maytag Support Development Corp.)

63A16147
II. TITLE: A discussion on demonstrating maintainability

AUTHOR: Burton H. Batchelor (The Boeing Co., Aero-Space Div., Seattle, Wash.)

III. TITLE: Designing for maintainability

AUTHOR: Raymond Kamm (Douglas Aircraft Co., Inc., Aircraft Div., Long Beach, Calif.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 339-343; p. 344-352; p. 353-355 (*see RATR 2256)

PURPOSE: To discuss the establishment, initiation, and control of a maintainability program (I); to discuss the reasons and procedures for maintainability demonstration of equipment (II); to discuss the ways in which the steps used in aircraft design affect maintainability (III).

ABSTRACT: I. The ease and economy with which a system can be maintained are a manifestation of the maintainability activity performed as a portion of the basic design effort. Specific maintainability requirements must be based on information furnished by the customer which includes downtime requirements, environmental restrictions, support resource limitations and qualitative program goals. These are used to furnish the design engineer with specific design guidance, including (1) design specifications, (2) a design for maintainability handbook, and (3) personal guidance. The design review presents an excellent opportunity to verify that maintainability requirements have been met. Factory assembly problems are very often reincarnated in the form of field maintenance problems, and provisions should be made to review fabrication problems. Careful adherence to the precepts which are presented will assure contractor capability to demonstrate the achievement of stipulated goals.

II. Maintainability demonstration is the procedure used to prove that specified requirements have been met. The military and industry both lack relevant experience. Opportunities for informal demonstration exist through observation of mockups, displays, and manufacturing processes. Information obtained here is useful

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in preparing for a formal demonstration, which can be direct observation of normal operation or based on performing special tests. Demonstration examples are presented, including actual plans for a tracking station maintainability evaluation and a review conducted on the Bomarc Weapon System. Necessary reports and personnel qualifications are cited. Lack of adequate experience with maintainability demonstration precludes making a definite conclusion as to its value.

III. In the design of a transportation system there are many factors which must be considered by the designer. Maintainability is only one of these. During early design, policies are formulated which give direction to the design team, e.g. no advance in state of the art. An early step is an aggressive simplification program, followed by a thorough reliability and dispatchability analysis. A trouble shooting procedure analysis is then conducted to see if valuable ground time can be saved. Upon completion of these studies the engineering design task assignments are prepared. Design reviews are held on resulting proposed designs with all specialty sections in attendance. The maintainability goals are demonstrated using mockups and checks of actual times. This process produces some remarkable maintenance results without penalizing the other design requirements.

REVIEW: An orientation for implementing a maintainability program by a government equipment contractor is provided in I. It cites many general things which "must be" and "should be" done. An interesting thought is the formal use of factory fabrications problems as an indicator of expected field maintenance problems.

The second paper (II) concentrates on maintainability demonstration and presents some details. Little mention is made of the statistical aspects of maintainability measurement. Anyone planning a maintainability demonstration would want to see this paper for possible ideas.

A short but good discussion of how the maintainability goal is considered in the design of manned aircraft systems is presented in III. It rings of experience and the cost-consciousness of commercial aircraft. A pleasing implication is that the design steps which are taken and the manner by which they consider maintainability are standard procedures used on every system which is designed. Some forms associated with the design steps are illustrated; Figures 6 and 7 are apparently reversed. ##

63A16148

Serial Number 2314
ASQC Code 813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: FAA reliability monitoring program

AUTHOR: George C. Prill (Federal Aviation Agency)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 356-359 (*see RATR 2256)

PURPOSE: To present a reliability program involving a part of the FAA role of monitoring the nation's air carriers as they maintain their aircraft.

ABSTRACT: The FAA has the general statutory role of promoting the safety and development of air commerce, and the particular role of monitoring the air carriers' inspection, maintenance, overhaul, and repair of their aircraft. For many years an attempt was made to gain reliability through informal control of overhaul periods. A technique was needed to deal more directly with all causal factors, including overhaul periods, procedures, personnel, and equipment design features. A trial program was planned by a joint FAA-industry committee. It was directed toward the control of reliability through an analysis of the factors that affect reliability, and it provided a system of actions to improve low reliability levels whenever they appear. The inflight failure of propulsion systems was chosen to start the new reliability data program. Alert limits were established from inflight records for a two-year period and would allow about 80% of the industry to stay satisfactory. Being in the alert serves as a flag to the FAA and the operator and requires the initiation of a corrective action program. Air carrier entry into the program has been voluntary, with an increasing participation. From the carrier standpoint, the results have been a more realistic approach to power-plant overhaul times, with numerous time increases granted which likely would not have been granted without the program. From the FAA viewpoint, the program is a big step forward toward inservice reliability control. Future steps will be a gradual expansion of reliability control through more attention directed toward the total air transportation system. (Author in part)

REVIEW: The reliability program described here appears to consist of the voluntary participation of air carriers in a control chart approach to propulsion system inflight shutdowns. Such other factors as operating procedures, basic engineering design, and manufacturing were cited as possible contributors to poor inservice reliability, but apparently were not included in the reliability program at that time. There appears to be opportunity here for an expanded reliability program. This paper makes interesting reading, more so from the viewpoint of an air carrier passenger than from that of a reliability technologist. ##

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63A16150

Serial Number 2315
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Trend analysis as applied to gas-turbine engines and aircraft mechanical equipment

AUTHORS: W. A. Spraker, J. P. Loomis, and F. L. Bagby (Battelle Memorial Institute)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 375-380 (*see RATR 2256)

PURPOSE: To show how analysis of performance trends can improve reliability.

ABSTRACT: If some parameters can be measured which are related to ability-to-perform or to quality, they can provide valuable information for the estimation of proximity of a failure. If these measurements are repeated from time to time, irregularities which are large compared to usual variations signal the likelihood of failure soon. In a turbojet engine, some good indicators are inlet temperature and pressure, engine pressure ratio, exhaust gas temperature, fuel flow, and speed. From these data, the appropriate measures of performance can be calculated. The mechanical integrity of the engine is indicated by rundown time, vibration amplitudes at several important frequencies, oil consumption rate and oil analysis (spectrographic). The quality of the landing gear retraction system is indicated by the time to extend or retract. The brake system can be monitored by any temperature differences between brakes after a stop. It is assumed here that any operation outside the usual has been properly noted.

REVIEW: This is an informative introductory paper on an important topic. The measurement of trends can show up irregularities which may have a big effect on performance during the next mission. ##

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11/65 63A16154 Serial Number 2316
ASQC Codes 861;864

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Operational data requirements for experience retention

AUTHOR: George R. Herrold (The Boeing Co., Aerospace Div., Seattle, Wash.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 406-417, 17 refs. (*see RATR 2256)

PURPOSE: To explain the need for and use of operational field failure data in eliminating modes of equipment failure from existing designs and preventing their recurrence in future designs.

ABSTRACT: Significant gains in operational effectiveness can be achieved by improving the rate of learning from field experience. Field failure data are usually not adequate. The problem is much more complex than changing a few data forms or tab runs. Needed are field failure specialists who report on check list items in their own words with minimized use of codes. This may require special contracting, as it is in addition to the work of the customary field technical representative. The field data are used by the customer for the immediate correction of operating deficiencies and maintenance procedures. In a like manner they are used by the contractor to improve the technical data, procedures, and processes he uses to build the equipment. Improvements in basic systems of operation are equally as important as immediate corrective action. Skilled specialists are needed to recognize immediate problems and to solve them. Other specialists are needed to objectively review failure experience and identify flaws in the basic company operations which result in modes of failure. In the first several years of an experience retention program many changes have been made to operating methods. (Author in part)

REVIEW: The tasks which are highlighted in this paper--field experience analysis for immediate and long-term corrective action--are performed to some extent in all organizations which use or produce equipment. The author's organization apparently believed that improvements are best obtained by formalizing this function and using specialized personnel. It is difficult to judge whether formalizing some traditional functions and creating specialists is the most effective approach. It is safe to predict that many traditional management and line personnel will not be readily receptive to the idea that customary field technical representatives cannot be trained satisfactorily to perform field failure functions, but rather that additional field failure specialists must be used.

In a private communication the author notes that on several large Air Force programs, such as B-52, IM-99, KC-135, and Minuteman, reliability field engineers were generally separately contracted for. He also notes that although such specialization may be practical on large programs, it would not be feasible on smaller programs. ##

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11/65 63A16155 Serial Number 2317
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Evaluation of mechanical systems service experience and its application to reliability in preliminary design

AUTHOR: William F. Johnson, Jr. (Curtiss Wright Corp., Curtiss Div., Caldwell, N. J.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 419-428 (*see RATR 2256)

PURPOSE: To present a simple system-reliability analysis method easily understood by and acceptable to preliminary designers of mechanical systems.

ABSTRACT: A simple method of reliability analysis for mechanical systems is needed. This allows the designer to include reliability along with weight, cost, etc. in his early tradeoffs. The assumptions are made that success-failure is an adequate description of the performance of the system and all its parts, and that the occurrence of premature removals of parts follows the Poisson (or exponential) law. The system is broken into its functioning parts and logic diagrams are made of the various failure modes. These diagrams are appropriately analyzed. Account must be taken of reliability improvement with system maturity.

REVIEW: While the analysis is a simplified one and undoubtedly has merit, the presentation of it in this paper is not clear. It would be very difficult to apply this method after reading the article. In particular, the assignment of actual numbers to failure rates is not illustrated and whether failure rates apply to parts or to functions is not clear. The use and analysis of logic diagrams are good ideas. The formula $P(sf) = P(cf)\ P(sf|cf)$ is not correct since there is more than one component. ##

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11/65 63A16162 Serial Number 2318
ASQC Codes 846;873

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Use and interpretation of reliability data for establishing maintenance requirements

AUTHORS: Charles E. Savo and Jerome T. Alpern (Lockheed-California Co.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 468-473 (*see RATR 2256)

PURPOSE: To provide a degree of clarification on the use of actual or estimated reliability information for maintenance analysis purposes.

ABSTRACT: Systematic analysis of designs by experienced maintenance engineers has emerged as a medium through which maintenance management programs can be integrated to give maximum logistic support effectiveness at minimum cost. Starting with the early operational phases of the equipment, the maintenance analyst can use failure data and reliability statistics if he interprets them properly. Conversely, the reliability engineer must appreciate the objectives of maintenance analysis in order to present his data in usable form. A need exists for improvement of the failure data reporting system of the military services to provide for complete follow-up of all components removed due to failure or suspected failure. Pure failure rates or mean-time-between-failures are not valid for establishing preventive maintenance schedules. The actuarial graphs discussed in this paper do provide a valid basis when related to actual field experience. Mean-time-between-failures cannot be used directly to determine manpower requirements or provisioning factors. Mean time between scheduled and unscheduled maintenance actions is the better unit of measurement. There is serious need for reduction of failure data from all sources to a categorized parametric form which can be used as a basis for decisions in new design. This is particularly true in the area of mechanical equipment. (Authors)

REVIEW: In the process of showing how indiscriminate use of failure rate information can lead to erroneous maintenance analyses, this paper also ends up showing why indiscriminate use can also lead to erroneous reliability analyses. Much attention has to be given in mechanical units to the validity of the widespread assumption of a constant failure (hazard) rate. This paper is based on maintenance analysis experiences of several military airplane systems, and it illustrates an increasing maturity in reliability and maintenance analyses. ##

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11/65 63A16165 Serial Number 2319
ASQC Codes 873;883

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Increasing operational effectiveness by attacking the time-to-repair

AUTHOR: Wallace H. Hanlon (ITT Federal Laboratories, 3700 E. Pontiac Street, Fort Wayne, Ind.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 486-490 (*see RATR 2256)

PURPOSE: To describe the design approach taken for a data display central in order to achieve virtually continual availability without true redundancy.

ABSTRACT: A brief description is given of the data display central (for the 465L AFSAC control system) in order to better show the systematic attack on downtime necessary to meet the mean time to repair requirements of six and twelve minutes for the various equipments. Preventive maintenance time as a part of total down time was eliminated by mandating that no preventive maintenance would interrupt operation. Each of the major equipments contains fault detection and monitoring circuitry; in addition, a status panel displays equipment status and provides an audible alarm when a fault is detected. An integrated test set provides the ability to exercise the digital equipments of the system. The man-machine maintenance tasks of detection, identification, repair, and validation are discussed. Of these, fault identification is the most nebulous area which is apt to be time consuming, and a fault study was conducted to ferret out the detailed knowledge of the equipment designers which would be useful. The amount and detail of the resulting maintenance information surprised all concerned. (Author in part)

REVIEW: This is a readable paper which is based on the actual experience of a concerted effort to design low maintenance time into a digital electronic system. It is largely discussion, and should be of interest to anyone attempting a similar task. ##

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 63A16166 Serial Number 2320
ASQC Codes 813;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Increasing operational effectiveness through mission oriented reliability improvement programs

AUTHORS: R. B. Muirhead and J. P. Wenzelberger (North American Aviation, Inc., Columbus, O.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63, p. 491-497 (*see RATR 2256)

PURPOSE: To discuss an approach to a reliability improvement program which concentrates on the functions for which an equipment was designed.

ABSTRACT: The modern weapon system is capable of performing a variety of mission functions. An analysis should consider the expected utilization of each component of the system for the expected mission distribution of the weapon system. Subsystem functional reliability models are constructed for each subsystem showing its contribution to each type of mission; this may result in several subsystem models. Analysis of reliability models has received considerable attention and only simple relationships are shown for illustrative purposes. The mission failure rates are calculated for critical items and are modified by the relative mission frequency to determine improvement priorities. Sensitivity curves are then examined for the operational effectiveness improvement which would result from component reliability improvement. In this manner, program efforts are oriented to those components where operational effectiveness payoff is greatest. (Authors in part)

REVIEW: Attention is directed to the fact that a modern weapon system has a range of missions and therefore will have a distribution of associated reliabilities. The paper emphasizes this point, largely by qualitative discussion, and otherwise presents widely used material. It is amply illustrated with accompanying diagrams and charts. ##

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63A16170

Serial Number 2321
ASQC Codes 872;873

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Maintainability indices for equipment designers

AUTHOR: H. S. Dordick (Radio Corporation of America, Princeton, N. J.; Now with Burroughs Corporation, Electronic Instruments Div., Philadelphia, Pa.)

SOURCE: Aerospace Reliability and Maintainability Conference, Washington, D. C., May 63 p. 513-517 (*see RATR 2256)

PURPOSE: To derive a few key design indices which are relationships between design parameters which can be traded off and maintenance requirements as stated in specifications.

ABSTRACT: Military specifications now clearly call for the assignment of numerical values to certain operational-design parameters such as maintenance times and failure frequencies. The circuit and packaging engineer must design in such a way that the measure of maintainability is some predetermined value. Unfortunately, the measures currently being proposed for maintainability are in terms of time, and are of little value to the circuit designer. Maintenance times must be translated for him into measures that are more directly related to design parameters such as the required number of calibrations or adjustments. A partial list is shown of the many factors from MIL-M-26512B which require a numerical representation. Several indices are defined, including calibration, adjustment, manpower economy, and equipment economy. It seems theoretically possible that a full set of indices can be properly derived and combined to synthesize an equipment downtime. Some mathematical details of an index derivation are given in an appendix. (Author in part)

REVIEW: An approach for analytically relating design decisions to numerical maintainability requirements is proposed. As the author notes, the paper presents some ideas which require further study and experimental application. There is little here that a designer or analyst can readily apply.

The author, in a private communication, has indicated that his plea for further study has been satisfied by the follow-on work reported in [1].

REFERENCE: [1] "Selecting between redundancy and repair in manned spacecraft: A designer's tool," by C. G. Vandervoort and H. S. Dordick, RAND memorandum RM-4325-NASA, Sept 64. ##

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65N31885

Serial Number 2322 -1
ASQC Codes 775;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Non-destructive reliability screening of electronic parts, using RF noise measurements

AUTHORS: H. Avil, C. Maronde, and L. Kirvida (Honeywell, Inc.)

SOURCE: Technical Report No. RADC-TR-65-71, Reliability Branch, Rome Air Development Center, Research and Technology Division, AFSC, Griffiss AFB, N. Y., Jun 65, 166p, 23 refs. (AD-618 469)

PURPOSE: To prove the value of RF noise measurements as a screening test for electronic parts.

ABSTRACT: This report describes an investigation and evaluation of radio frequency (RF) noise in silicon diodes and tantalum capacitors. The final data of the study confirm the original hypothesis that RF noise can be used to separate good from bad parts. In both the diode and capacitor tests, components that had high RF noise were more likely to fail than the quiet components. In the case of the diodes, the ratio was approximately two to one; for the capacitors, three to one. These ratios are computed from 18 weeks of test time for the diodes and 12 weeks for the capacitors. Even more significant is the greater difference in fraction failing during the initial 250 hours of life test. In this period, noisy diode failures were 2.6 times higher than quiet diode failures, and noisy capacitor failures were 6.2 times higher than the quiet capacitor failures.

There were over 20,000 diodes screened. Of this total 146 (0.7%) had excessive noise. However, only 86 of the noisy diodes passed all other specifications for this component. Similarly for the capacitors, 67 (0.7%) of the 10,000 screened passed all specifications, but were excessively noisy. These percentages are within the range anticipated for this type of test.

An extensive effort to optimize the measuring techniques for both the diode and capacitor yielded positive and negative results. On the positive side it was found that transformer coupling the diode output allowed the use of a less sensitive and less expensive receiver. However with the NF105 receiver that was used in the screening, the direct coupling method proved best. Work on the capacitor circuit yielded no real advantages.

Along with the normal noise sources in semiconductors, microplasma noise generation was shown to be a significant contributor to the detected RF noise. A darkroom photograph of a sectioned diode verifies the existence of these microplasmas. When four noisy diodes and a quiet one were dissected and photographed, all four noisy diodes showed physical abnormalities while the quiet diode showed none. This indicates that RF measurement techni-

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ques are useful in revealing components that are physically faulty. The general conclusion drawn from this work is that the results do substantiate the higher incidence of failure of components containing high RF noise over components that do not exhibit such noise.

In addition to theoretical discussions of failure mechanisms and descriptions of test procedures, the report contains extensive life test data and illustrations. The more pertinent references from a detailed literature search are cited. (Authors in part)

REVIEW: This is a most promising method of screening out potential early failures in electronic components. The report is an extensive up-to-date treatment of an important topic. The early part of the work dealing with diodes is reported in the paper covered by RATR 2222. The authors' recommendations that this work be continued should certainly be heeded. Some people are even trying to use this method to check assemblies of parts, with some apparent success. ##

64A24528

11/65

Serial Number 2323
ASQC Codes 821;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Design of data transmission structures with optimal reliability

AUTHORS: A. K. Kel'mans and A. G. Mamikonov (Moscow)

SOURCE: Automation and Remote Control (A translation of Avtomatika i Telemekhanika, a publication of the Academy of Sciences of the USSR), vol. 25, p. 193-197, Aug 64 (Instrument Society of America, 530 William Penn Place, Pittsburgh 19, Pa.) 64A19431

PURPOSE: To present an algorithm for constructing structures with optimal reliability by constructing one which has its points joined to the point 0 by the shortest (most reliable) paths.

ABSTRACT: High reliability in connection structures can be achieved by complete interconnection, with tremendous redundancy. This article shows how to construct optimal structures with considerably less redundancy. A point 0 is selected to which all information is to be transmitted. Each arc between vertices has a weight q, and a quantity c is assigned to each of the vertices. First an algorithm is proposed which permits cycles in the structure. It is proved, however, that for structures in which there exists one fully determined path for transmission to the point 0 there are no cycles. A simpler algorithm can then be presented.

Four definitions are stated:

1. An isolated point is one which at a given stage is not connected to any other point.
2. A fragment is a subset of points including the point 0, such that all the points are connected by straight arcs forming a cycle-free structure.
3. The distance from an isolated point to a point on a fragment is the sum of the probability of failure for the selected path and the quantity c pertaining to the point on the fragment. (The algorithm for finding c is presented.)
4. The distance from an isolated point to a fragment is the minimum of its distances to the individual points on the fragment. (The shortest path is that for which the sum of the probabilities of failure is minimal.)

The structure desired is found by (a) joining the point 0 to its nearest neighbor by the shortest arc, and (b) in each subsequent step, joining the fragment obtained in the preceding step to the nearest isolated point by the shortest arc. The result is the most reliable structure. An example is given.

REVIEW: This is a useful article, and the method is claimed to be more efficient than another algorithm (by Ford) which is cited. The paper contains proofs of its contentions, but the symbology is not always defined, which will bother some readers. ##

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11/65 64A24529

Serial Number 2324
ASQC Codes 431;821

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE Stochastic automata and the problem of constructing reliable automata from unreliable elements. I

AUTHOR: G. N. Tsertsvadze (Moscow)

SOURCE: Automation and Remote Control (A translation of Avtomatika i Telemekhanika, a publication of the Academy of Sciences of the USSR), vol. 25, p. 198-210, Aug 64, 9 refs. (Instrument Society of America, 520 William Penn Place, Pittsburgh 19, Pa.) R 64A19432

PURPOSE: To show how to achieve a given reliability in an automaton over a given number of cycles, using unreliable elements.

ABSTRACT: This is the first part of a two-part paper (the second part will deal with vote-taking elements). This article is the direct descendant of the work of von Neuman and Moore and Shannon cited in its references. Here a stochastic automaton is used as the model, and its validity for this purpose is proven. The first part of the paper itself consists of two parts: The justification of the use of the stochastic automaton chosen, and the determination of the required reliability of individual elements. By means of a state matrix approach, and neglecting all powers of the temporary-breakdown probability greater than the first, the transition matrix is put in the form $\bar{R} = R + \epsilon B$, where R is the state matrix, ϵ is the error probability of each element, and B is the error matrix. It is assumed that the stochastic-automaton model has only as many states as the corresponding ideal automaton.

The first stage of reliability synthesis is the determination of the reliability demanded of individual elements to give a required reliability (over a given number of cycles) for the entire automaton. The second is the actual synthesis of the reliable automaton using the elements from the first stage. In performing the first stage the author uses three different approaches, depending on the nature of the automaton. First he raises the stochastic matrix to a power equal to the desired number of operating cycles. For more complex cases a second approach is to use an entropy estimate. The derivations and explanations for this method are given. The third method uses the properties of the characteristic roots of the matrices. An example is given.

REVIEW: This work is a valuable contribution to the literature of automaton reliability. Unfortunately, it is quite difficult to read, partly because it is not well organized, and partly because of the translation, which leaves a sentence dangling in at least one place, and uses improper compounding elsewhere. The author is rather cavalier with his "it is not difficult to...", etc., which will annoy some readers. This is not a tutorial paper, but it should be useful to the specialist in automata. ##

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Serial Number 2325
ASQC Codes 820;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Self-correcting diode networks

AUTHOR: E. I. Nechiporuk (A. A. Zhdanov Leningrad State University)

SOURCE: Soviet Physics-Doklady, Cybernetics and Control Theory, vol 9, p. 422-425, Dec 64

PURPOSE: To show that, in circuits which have failed by diode opening, the complexity of correcting networks is a function of the number of openings, and to give the function, with proofs.

ABSTRACT: The author presents four theorems having to do with the self-correction property of diode networks where only the open-circuiting of diodes is to be corrected. Most of the paper constitutes definitions and mathematical proofs of the theorems.

The first theorem states that the complexity required of a network for the correction of m-fold opening increases by a factor of at least $C(m+1)$ over the complexity of the regular network to generate the same function without correction. Here the depth is assumed to be two. The constant C is the number of ones in the matrix for the circuit, divided by the maximum density of its submatrices.

The second theorem states that the density of (p,q) matrices containing αpq ones approaches the binary log of p divided by the binary log of $1/\alpha$, under certain given conditions. The other two theorems show that for conditions of low matrix density the complexity factor approaches $m+1$.

REVIEW: This is a concentrated mathematical treatment of a class of self-correcting diode networks. The author supplies a continuous flow of symbols and definitions, which breaks up the continuity of the presentation, making the paper extremely difficult to read. It would be better to tabulate definitions, and then to give theorems and their proofs without interruption, summing up the results at the end. ##

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64N29457

Serial Number 2326
ASQC Code 872

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Justification for subdividing complicated radio apparatus into blocks with controllable operating ability

AUTHOR: L. L. Barvinskiy

SOURCE: Radio Engineering, No. 1, 1964, Joint Publications Research Service, Washington, D. C., 17 May 64, p. 30-38 (NASA accession number N64-29457)

PURPOSE: To find an optimum size for subsystems whose proper functioning is to be monitored by fallible equipment.

ABSTRACT: If subsystems are monitored by fallible fault detection apparatus, there is some optimum size of the subsystems to make the system reliability a maximum. The following assumptions are made:

1. The time for repair of the apparatus has an exponential distribution and consists of the time to find the malfunction and the time to eliminate it; the average time of elimination of the malfunction is constant and the average time of finding the faulty element depends on the number of controlled points.
2. During the course of its operation, the apparatus either is used completely or else is turned on in expectation of use.
3. The number of spare parts necessary to effect the repair is unlimited and any delay because of lack of parts is disregarded.
4. The duration of the periods during which the apparatus is not employed has an exponential distribution and does not depend on the instant preceding the use of the apparatus.
5. Failure of the apparatus does not depend on the frequency or duration of the use periods, and is determined only by the time during which it is turned on.
6. The system is conveniently divisible into any number of subsystems.

The probabilities of failure that vary with the size of the subsystems are calculated and the optimum number of subsystems is determined. Under certain reasonable simplifying assumptions, the equations can be evaluated. An example is shown.

REVIEW: This is a translation from a Russian publication. Not all of the mathematics was checked, but it appears to be reasonable. Some of the translated text is hard to follow. No mention is made of the breadth of the maximum, to show how critical the number of subsystems is. It is likely that similar results are available in clearer form in the USA literature. ##

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11/65 64N32915

Serial Number 2327
ASQC Code 833

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Estimate of reliability of ceramic tubular capacitors

AUTHORS: M. M. Nekrasov and A. N. Franchuk

SOURCE: Radio Engineering, No. 3, 1964, Joint Publications Research Service, Washington, D. C., 21 Oct 64, p. 167-174 (NASA accession number N64-32915)

PURPOSE: To discuss a screening test for ceramic tubular capacitors.

ABSTRACT: To merely run life tests on capacitors does not improve their reliability, nor show how to do so. The theory of operation of these capacitors leads one to correlate short life with very inhomogeneous fields in the dielectric. Very inhomogeneous fields in turn cause a high dissipation factor. Thus, at an appropriate frequency and temperature, capacitors which have a high dissipation factor were expected to have a shorter life (in terms of dielectric failure) than those with a low dissipation factor. Experiments have confirmed this. Measurements were made at 400 cps and temperature from 60 to 130°C.

REVIEW: This would appear to be an effective screening test when performed under the proper conditions. Some of the conclusions in the paper may be optimistic, but do not detract substantially from it. ##

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11/65 Serial Number 2328
ASQC Codes 833;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Eliminating catastrophic failures

AUTHOR: John Baugher (Electronic Measurements Company, Inc., Eatontown, N. J.)

SOURCE: Electrical Design News, vol. 10, Jan 65, p. 54-56, 61

PURPOSE: To analyze two power-supply arrangements for reliability.

ABSTRACT: Consider two power-supply arrangements wherein the output is monitored. On one if the output is bad, the monitor removes power; on the other, some internal point is monitored and if that point becomes critical, the output is removed. The probabilities of removal of improper voltage are then calculated. The former case is shown to be the better arrangement.

REVIEW: The title of the article is misleading, but the article does treat a reasonable problem. The calculations of probabilities seem somewhat belabored. The discussion implicitly assumes statistical independence of failure events and that the events are adequately described by the dichotomy of good/bad. Both of these may limit the application of this comparison. As might be expected, the arrangement containing a product labeled with the author's company proves to be the better. No doubt other numerical examples (although not necessarily typical ones) could be found which illustrate the reverse. (In one place, probabilities are used instead of events. In another the reasoning is not clear as to why one arrangement must be better.) ##

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Serial Number 2329
ASQC Codes 775;835

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Detecting hot spots in integrated circuits

AUTHOR: --

SOURCE: Electrical Design News, vol. 10, Apr 65, p. 102-108

PURPOSE: To describe infrared testing of integrated circuits.

ABSTRACT: The temperature of any part of an integrated circuit obviously affects its life. Relative temperatures on the surface may show up defects in design or manufacture. Examples are given. Temperature maps of a microcircuit can be constructed by measuring the radiation and then correcting for emissivity. Some equipment is described.

REVIEW: This is a rather intensive description of what can be done with infrared testing of microcircuits. Several references are given. One calibration method not mentioned is that of taking the infrared pictures with the part held at a uniform temperature. (The sentence "... isothermal maps can be drawn by connecting...points of equal radiation..." is obviously an overlooked error. The correct procedure is mentioned several times elsewhere.)

For other references on the use of infrared techniques to enhance electronic reliability see RATR 626, 993, 1978, 1991, 2126 through 2129, and 2272. ##

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65A15429

Serial Number 2330
ASQC Codes 720;837;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Integrated-circuit reliability

AUTHOR: Paul Pittman (Westinghouse Electric Corp., Molecular Electronics Div.)

SOURCE: Electro-Technology, vol. 75, Jan 65, p. 37-40

PURPOSE: To discuss some aspects of the reliability of integrated circuits.

ABSTRACT: The life of non-defective integrated circuits is so long that it is hard to measure. One way to improve the life, without knowing exactly what it is, is to eliminate potential failure mechanisms such as faulty encapsulation, poor internal leads, bad intra-connections and inadequate passivating oxide. This is done by process controls which, in addition to overall feedback, make checks for lack of failure mechanisms during production. Accelerated testing such as step-stress is a way to keep track of the ability of parts to resist being degraded--even though an estimate of life is difficult. Measuring small irreversible changes in parameters may be a way to screen out potential early failures.

REVIEW: This is a discussion of many of the problems associated with predicting the life of integrated circuits. In the discussion on statistics there are some misleading statements. Instead of them, it may be said that:

1. All of the probability distributions are distributions of a random variable--by definition--not just the exponential.
2. It is often the case, as in integrated circuits, that the applicability of a particular distribution has not been justified by extensive data and analysis.
3. The log-Normal distribution is not implicit in step-stress testing--nor is any other distribution; it is commonly used.
4. Statistical "proof" of distribution parameters is very difficult (for long-lived/high quality items) if complete ignorance about the parameters is assumed. Great strides can perhaps be made if some way is found to account adequately for the prior knowledge that does exist.

There is an implication that imperfections in the crystal structure of silicon greatly reduce reliability. Certainly, up to a point, they have negligible effect since they are introduced during any heating cycle. Accelerated testing is not a new reliability characterization technique. Many of our reliability data on all components come from accelerated testing (although the manufacturer may extrapolate it down to operating conditions before publishing it). There are real problems with predicting the life of integrated circuits and this article discusses many of them well. ##

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11/65 Gr

Serial Number 2331
ASQC Code 810

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Charting reliability for maximum effectiveness

AUTHOR: Harold M. Gordy (Giannini Control Corp., Glendale, Calif.)

SOURCE: Electronic Industries, vol. 23, Oct 64, p. 59, 60, 63

PURPOSE: To discuss the problem of obtaining an effective place in the organization for the reliability function.

ABSTRACT: The reliability function should be centralized because it constitutes a diverse group of people each of whom may not really have another home. The group must make the proper tradeoffs with the reliability money. It must cut across electronic-mechanical lines. The biggest disadvantage is that the reliability manager may try empire-building. A table is provided showing advantages and disadvantages of having the reliability manager report to the general manager, the chief engineer, and the project engineer.

It is important to assign the group to a progressive superior with a broad background and who gets along well with his peers.

REVIEW: Many of the points in this paper are controversial and thus should not be accepted as gospel. This is not to say that they are not worthy of consideration or are not best in some circumstances. For example, it is recommended that reliability not be in a quality assurance group. Some people feel rather strongly that reliability is but one facet of assuring the customer the best quality for his money. The author largely considers what happens when the reliability group has good people in it. One must also consider what happens when they are not so good. After all--on the average, engineers are pretty average.

The author in a private communication has pointed out that he makes a distinction between quality assurance and quality control. In the context which he has in mind, he considers it to be acceptable to have quality control and reliability report to a manager of quality assurance. However, he feels that placing a reliability group under quality control is quite unacceptable. ##

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9

Serial Number 2332
ASQC Codes 711;815;830

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability goals depend on new materials

AUTHOR: Sidney Feldman (Associate Editor, Electronic Industries)

SOURCE: Electronic Industries, vol. 23, Dec 64, p. 100-104

PURPOSE: To show the need for new materials and their management.

ABSTRACT: Defense, atomic energy, space and other programs are limited by materials inadequate to withstand severe temperature, pressure, radiation, corrosion and stress environments. New forms and reinforcement methods produce essentially new materials; examples include honeycomb, fiber metals, and laminates. Some materials and product producers are integrating vertically to control operations from raw materials through finished goods. Engineers can no longer rely upon old cookbook formulas, rules of thumb, and specifications.

Many companies find that a Materials Group can provide valuable assistance to designers and production people. Better development, manipulation and management of materials are necessary since materials are the basis of parts, equipment and systems. The horizons in materials have never been further away--there is room for everyone.

REVIEW: Those who are already convinced need not read the paper; those who are not would do well to study the message seriously. One point which is mentioned, but needs emphasis, is the problem of specifications for materials. Even some of our ordinary materials such as steel and common plastics lack specifications which are functionally meaningful. Designers not only cannot specify important properties--they do not even know exactly what they are. Intelligent widespread use of materials will be hampered in this way for a long time to come. ##

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11/65 66A13279

Serial Number 2333
ASQC Code 838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability through redundancy

AUTHORS: Norbert Seiden (General Precision Aerospace, Kearfott Div., Reliability Engineering Dept., Little Falls, N. J.)

SOURCE: Electronic Industries, vol. 24, Jul 65, p.65-66

PURPOSE: To discuss the basic approaches for increasing reliability.

ABSTRACT: Reliability can be increased by improving worker attitudes and skills, by parts improvement, design reviews, etc. Sometimes, when all else is not enough, redundancy must be used. If two elements are logically in parallel and their failure probabilities are independent, the failure probability of the combination is reduced. The effective failure rate is $\bar{\lambda} \approx \lambda^2 T$ where λ is the hazard function of each element, T is the mission time, and $\lambda T < 0.1$. Note that $\bar{\lambda}$ is a function of mission length whereas λ is not.

REVIEW: This is a well known result and is adequately covered in the literature. Not all elements, of course, are described by a λ which is independent of time. It is most important also, to explicitly state "statistical independence" rather than just "independence" since the failure probabilities of two elements can easily be physically independent yet statistically dependent.

This type of paper has the grave disadvantage of giving engineers a superficial treatment. If that is all they can understand, then they need more study before applying it. If they are more advanced, then the superficial paper is unnecessary. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The role of compound formation on semiconductor device reliability

AUTHOR: B. Selikson (Sylvania Electric Products, Inc., Woburn, Mass.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 365-377, 6 refs. (*see RATR 2221; AD-617 715; CFSTI Prices: HC $8.00, MF $2.25)

PURPOSE: To review the purple plague problem in silicon planar devices.

ABSTRACT: A black mechanically-weak electrically-poor plague is rapidly formed when gold wires are bonded to aluminum metalization regions in silicon devices and then are baked at 200°C to 300°C. It is a result of aluminum-gold compound formation catalyzed by the presence of silicon. There is a ternary interaction of silicon, aluminum and gold in the three-component system. The black plague formation and bond degradation occur as rapidly when bonds are formed on top of the oxide as when formed directly on the silicon. The ternary interaction mechanism applies even on top of oxide as a result of reduction of silicon dioxide with aluminum to produce silicon. The mechanism also applies to devices when heated at 200°C, and is thus a very important failure mechanism and is applicable to all planar diodes, transistors and integrated circuits. Various metalization-wire methods are reviewed and possible compounds formed in these systems are summarized. The simplest metalization system, relatively free of metallurgical reliability problems, is aluminum wire on aluminum. (Author in part)

REVIEW: The extent of the plague problem as a failure mechanism in silicon devices which are well made and run within ratings is somewhat overrated by the author. It is most likely to occur in accelerated tests. The discussion of the plague problem itself is good, and much fruitful work appears to have been done.

The treatment of various other metallurgical systems is brief and not complete. Other factors are important besides metallurgy and some systems are not mentioned. ##

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Serial Number 2335
ASQC Codes 711;714;720

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Radioactive tracers in semiconductors

AUTHORS: William Salmre, Ralph Gorman, and Carlos Figueroa (United Aircraft Corp., Norden Div., Norwalk, Conn.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 378-388, 7 refs. (*see RATR 2334)

PURPOSE: To show the use of radioactive tracers in determining the ease of removal of chemicals for the processing of silicon.

ABSTRACT: In the manufacture of silicon integrated circuits certain undesirable atoms or ions can remain on or in the silicon wafer or the passivating SiO_2 layer. These originate in the chemical and physical operations such as lapping, photolithographic etching, diffusions and treatments necessary for the formation of metal contacts. Many of these unwanted impurities are capable of degrading device performance and causing failure. For example, high concentrations of phosphorus in SiO_2 layers will result in the lowering of its dielectric strength.

Since the number of atoms or molecules responsible for a failure need not be very large, radioactive tracers offer a general method for studying these kinds of failures. Thus far the amount of residue left behind the radioactively tagged $C^{14}H_3OH$, $H_2S^{35}O_4$, $NaCr^{51}O_4$ and HCl^{36} has been investigated. Silicon slices were thermally oxidized with steam, a solution containing the radioactive chemical was applied, and the slices were processed through steps similar to those used in the manufacture of integrated circuits. Residual radioactivity was measured after each process step.

Certain chemical cleaning treatments of the slices are more effective in the removal of the radioactive residues than others. One of the most effective treatments for the removal of impurities seems to be an immersion in HF. Unfortunately, the presence of an HF residue on the surface of SiO_2 or a change in the nature of the surface produced by HF may also be detrimental to device performance. Difficulties due to the short half-life of fluorine (1.87 hours) have precluded its use so far but it should be investigated. (Authors in part)

REVIEW: This technique certainly has application to the problems of silicon processing technology and this is a good example of its use. The results were not startling, but that does not detract from their value. ##

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12/65 65N30325

Serial Number 2336
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Failure mechanisms in high power four-layer diodes

AUTHORS: W. Schroen, J. Beaudouin, and K. Hubner (Shockley Research Laboratory, CLEVITE Corp., Semiconductor Div., Palo Alto, Calif.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 389-403, 14 refs. (*see RATR 2334)

PURPOSE: To give an account of developmental life tests.

ABSTRACT: High power four-layer diodes which failed during life tests were investigated in order to determine the reasons for their failure. The studies of the silicon chips have shown that the reliability of the diode can be limited by four failure mechanisms; nonuniform turn-on, hot spot development, thermal fatigue, and surface breakdown.

Diode burn-out which occurs after the first few pulses at high current gives evidence of nonuniform turn-on of the diode which results in local heating during a single pulse. The local heat can reach temperatures at which the silicon and contact-metal alloy further, finally short-circuiting the device. Nonuniform turn-on, usually caused by crystal defects, can be minimized by an appropriate design of the shorted emitter and proper triggering of the device.

When the damage of the diode by local melting of the silicon-metal-alloy occurs after many pulses (of the order of 10^3 or more) at appropriate repetition rates it indicates the slow build-up of a hot spot and a subsequent burn-out. These hot spots are formed by lateral thermal-instability. The development of hot spots can be minimized by proper mounting of the silicon chip.

Another failure mode shows a gradual deterioration of the device characteristics until the center junction is finally short-circuited without melting the silicon-metal-alloy. It can be speculated that the reason is either thermal fatigue or surface damage. In the first case, the expansion-contraction sequence of the chip as a consequence of the high currents passing through it causes fine cracks; the effects can be minimized by using a hard solder. In the second case, the failures by surface damage can be avoided by beveling the silicon chip and applying silicone rubber as a protective getter. (Authors in part)

REVIEW: This is a good report on what appears to be a well-executed program of product analysis and improvement. The analysis is especially interesting because of the more complicated conceptual models that had to be developed to represent device behavior. ##

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12/65

65N30327

Serial Number 2337
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Some failure modes of double diffused silicon mesa transistors

AUTHOR: A. A. Bergh (Bell Telephone Laboratories, Inc., Allentown, Pa.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 421-432, 11 refs. (*see RATR 2334)

PURPOSE: To explore different failure modes of a medium-power double diffused n-p-n silicon mesa transistor.

ABSTRACT: This paper discusses two different failure modes which have been observed on double diffused silicon n-p-n mesa transistors. (a) Bulk failure: In the presence of bare copper in an oxygen free ambient, power aging degrades the emitter parameters and gain. Only partial recovery can be achieved by etching into the bulk silicon or by heating the device at 300°C. (b) Surface Failure: In gold plated and/or oxygen backfilled cans, soft, loopy reverse junction characteristics develop under both temperature and power agings, first on the collector and later on the emitter. Both junctions recover completely upon opening the can and drying the transistor surface.

Surface failure is caused by water adsorption over the surface of the silicon wafer. Experimental evidence, including aging experiments in atomic hydrogen, is presented to demonstrate that the bulk failure is caused by copper contamination in the bulk silicon. Copper is transferred from the can to the wafer via a volatile hydride. It diffuses into the silicon and becomes electrically active during power aging. Qualitative explanations are offered for both failure modes: (a) Surface failure is due to surface states introduced by the adsorbed water and/or ionic conduction. (b) In order to explain bulk failure, the solubility and precipitation of copper is examined over the transistor profile and the effect of field on the migration of copper in silicon is taken into account. (Author in part)

REVIEW: These particular failure mechanisms are not often reported in the literature. It would be interesting to know just how important they are in causing failures of devices in the field (although that problem has no bearing on the validity of this work) and in what types of devices they are operative. ##

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12/65 65N30328 Serial Number 2338
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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Investigation of surface breakdown by light scanning

AUTHORS: W. W. Hooper and W. Schroen (Shockley Research Laboratory, Clevite Corp., Semiconductor Div., Palo Alto, Calif.)

SOURCE: Physics of Failure in Electronics Volume 3, Apr 65, p. 433-451, 18 refs. (*see RATR 2334)

PURPOSE: To obtain a better understanding of surface breakdown and thus improve the reliability of silicon planar devices.

ABSTRACT: Experimental investigations of surface breakdown in planar p-n junctions using the technique of photoscanning are reported. A reduction in device breakdown voltage upon illumination of small areas of the oxide layer close to the p-n junction has been observed. The results suggest certain failure mechanisms in oxide-covered silicon p-n junctions and methods to prevent them. A model is presented which describes the variation of the breakdown voltage by dividing the space charge layer near the interface into two regions: an ionization region containing a high electric field, and a trapping region. It is assumed that the electrons generated by the illumination change the charge state of the traps in such a way that the electric field within the ionization region is increased. The nature of the traps is not known, but further investigations are planned to elucidate details of the model. (Authors in part)

REVIEW: This paper fits the concept of "physics-of-failure" very well. It deals with a very basic subject which can have many applications. The report is well written and the experiments appear to have been conceived and executed with care. The historical introduction is especially helpful to those who are non-experts in this field. ##

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Serial Number 2339 -1
ASQC Codes 802;820;830
840;850;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability Engineering

AUTHORS: Engineering and Statistical Staff of ARINC Research Corporation; Edited by William H. von Alven (ARINC Research Corporation, Annapolis Science Center, Annapolis, Md. 21401)

SOURCE: Prentice-Hall, Inc., Englewood Cliffs, N. J., 1964, 593p, $14.95

PURPOSE: To present the practicing engineer and senior-level engineering student with a unified introduction to the concept of system effectiveness--relating mission reliability, operational readiness and performance capability.

ABSTRACT: The text begins with a discussion of system effectiveness concepts and definitions. Basic probability and statistics concepts are then presented. Useful system analysis techniques are described and illustrated, including methods for reliability functional analyses (models and prediction), for maintainability analysis, and for quantification of system effectiveness. A chapter is then presented on engineering techniques of established value in designing for reliability and maintainability. The several following chapters cover reliability and quality guarantees in part and equipment specifications employing sampling procedures; they also outline procedures for reliability demonstration tests. The relationships between cost and effectiveness are discussed, and an elementary discussion on costing of a support operation is presented. Well-proven reliability management concepts are discussed in the concluding chapter. Appendices include a list of related government documents and numerical answers to the problems. (Authors in part)

REVIEW: This text covers a wide scope of material, most of which is rather standard and has appeared in papers and reports. Approximately one-third of the content is qualitative discussion, with the remainder being quantitative methods. The qualitative material is timely, covering systems effectiveness concepts and some of the related areas such as data handling procedures and design techniques. The quantitative contents are elementary and application-oriented. Analytical complications are avoided, with little emphasis on assumptions, derivations, and how the formulas for application are obtained. Also, emphasis of the quantitative material is on attaching numbers to explicit indexes such as failure rate, reliability, availability, and mean repair time. Methods of reporting and processing field failure data are well covered.

There is little quantitative material on the area of performance degradation as related to reliability assurance. The book is weak in such areas as corrective action programs, parts reliability improvement programs, and reliability growth during research and

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development phases. Computer simulation methods for the reliability analysis of complex systems are not treated. The use of typical examples from practical reliability programs would have enhanced the presentation.

Each chapter in the book stands on its own, and there is some discontinuity in the flow of the presentation. There is also some inconsistency in the background level expected of the reader. For example, Chapters 2 and 3 treat elementary mathematical and statistical concepts in detail, whereas the Weibull function is given a very sketchy treatment (Section 5.9). The reader who needs the detail of Chapters 2 and 3 will need to dig elsewhere for needed background on such other topics as the Weibull and extreme value distributions.

The text would be most useful as a reference for those interested in applications and those who are relatively new to but not entirely unacquainted with the topic area. It is not ideally suited for a senior engineering text, being handicapped by the lack of basic quantitative treatment and the need for some experience in order to piece together the contents for continuity and possibly dig out additional information as mentioned above.

In a private communication the editor of the book has pointed out, quite correctly, that considerably more information is now available in the areas specified by the reviewer than was the case when the manuscript was completed. He has commented further as follows: "We are nevertheless pleased that this text was the first to document a number of reliability assurance techniques that are now considered standard practice.... The text made its first appearance in 1960 and subsequently underwent four revisions--the last of which was in late 1962 and early 1963. The text material in its present form has been in use about three years although the Prentice-Hall edition has been available approximately 18 months. Since 1960, approximately 10,000 copies have been distributed in both the Prentice-Hall edition and the earlier loose-leaf versions.... In our opinion, the text has had an important impact during the development of reliability as a formal discipline and it should continue to be of value as a source of basic concepts for both reliability and system effectiveness." ##

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ASQC Code 824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Estimating cyclical life for equipment experiencing only wearout failures

AUTHOR: J. E. Comer (Gulton Industries, Inc., Engineered Magnetics Div., Hawthorne, Calif.)

SOURCE: EM Report No. 1524, Engineered Magnetics Div., Gulton Industries, Inc., Hawthorne, Calif., Jun 64, 9p but see 65A26059

PURPOSE: To show how to calculate reliability when the lifetime distribution is Gaussian.

ABSTRACT: Given that the lifetime distribution of a part is known to be Gaussian, it is shown how the reliability of the part for a given mission can be calculated.

REVIEW: This is a revision of the paper covered by RATR 2156. Unfortunately the revision has done little to improve the gross inadequacies of the original. Confidence bounds and levels are not treated correctly. The quantity M_c which is "defined" to be "the measured average lifetime", presumably a random variable, is equated to certain constants in Equation (2). In fact M_c should be considered as the lefthand boundary of a critical region set up to test the hypothesis that $\mu = \mu_c$ vs $\mu > \mu_c$ when σ is known, where μ and σ are the mean and standard deviation of the Gaussian variable. The discussion on the use of the t distribution is not needed since assuming that T_R (the 1 - R percentile) and $Q = \sigma/\mu$ are known is equivalent to assuming that both μ and σ are known. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The reliability of parallel-sequential and sequential-parallel redundant systems

AUTHOR: Leo A. Aroian (Space Technology Laboratories, Inc., Electronics Div., Redondo Beach, Calif.)

SOURCE: Report No. 6121-7546-TU-000, Space Technology Laboratories, Inc., Electronics Div., Redondo Beach, Calif., 8 Oct 63, 5p

PURPOSE: To obtain system reliability formulae in terms of part reliabilities for parallel-sequential and sequential-parallel redundancy configurations.

ABSTRACT: Reliability formulae for systems in parallel-sequential and sequential-parallel redundancy situations are obtained in terms of the individual part reliabilities. Examples illustrate the theory.

REVIEW: This is a good, brief mathematical paper which gives some slight generalizations of earlier work by the author (see RATR 124). A comparison is made between a parallel-sequential system and a sequential-parallel system, each having the same number of identical parts, which shows that the reliability of the first is uniformly better than that of the second. ##

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12/65 63N21912 Serial Number 2342
ASQC Codes 813;815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability program evaluation procedures

AUTHOR: --

SOURCE: NASA SP-6002, Program Standards, Office of Manned Space Flight, National Aeronautics and Space Administration, Washington, D. C., Sep 63, 51p

PURPOSE: To establish uniform standards for evaluating reliability practices; to identify reliability problems; to permit evaluation of the various methods of controlling an area leading to improved reliability.

ABSTRACT: This document was established to serve as a standard to assure consistent evaluations of reliability procedures and controls being applied to Manned Space Flight Programs. The Office of Manned Space Flight is responsible for establishing evaluation procedures and monitoring their implementation. The cognizant NASA Center is responsible for implementing an effective program of periodic reliability program evaluations; specific responsibilities are detailed. Reliability program activities consist essentially of a network of interrelated procedures and controls to assure an end product which meets the needs. The twelve major activities are described in NPC 250-1, Reliability Program Provisions for Space System Contractors. An evaluation of the degree of effective coverage for each activity area is established by determining the importance of individual work elements and by the degree of effective coverage provided for each within individual activity areas. An over-all program evaluation can be developed by compiling the results of the various activity area evaluations. Basic steps of the evaluation procedure are outlined, scoring methods are discussed and illustrated, and a complete set of checklists for all work elements in each activity area are included. (Authors in part)

REVIEW: As these procedures are keyed to reliability specification NPC 250-1, they also reflect the accumulated experience and completeness of NPC 250-1. NASA SP-6002 will be useful to those initially planning a reliability program, as well as to those reviewing an existing program. As with most procedures and manuals, it will be of primary value to newcomers in reliability and to those dealing with the agency which sponsored the document. Of course the most important results from these and any evaluation procedures lie in the insight and knowledge gleaned from conducting the evaluation and in the resulting program changes, rather than in the scoring numbers which are assigned. RATR 1495, 1761, and 1826 also relate to NPC 250-1.
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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Aerospace weapon-system reliability: implications for management

AUTHOR: Mohamed Farouk el Hitami

SOURCE: Doctoral dissertation presented to the School of Business Administration and the Graduate School of the University of Oregon in partial fulfillment of the requirements for the degree of Doctor of Business Administration, Jun 64, 144p, 27 refs. (Xerographic copies may be purchased from University Microfilms, Inc., Ann Arbor, Mich., order no. 64-12,156)

PURPOSE: To describe an investigation into the field of reliability engineering and to examine its implications for management.

ABSTRACT: The dissertation is divided into four parts: (1) concepts, (2) analysis, (3) organization, and (4) conclusions. A reformulation of the framework of reliability engineering is made with the purpose of making the basic concepts more understandable to the manager. Included are discussions of such aspects as effect of environments and complexity on reliability, failure types, and reliability prediction. A simplification is made of the basic mathematical and systems engineering techniques of reliability analysis. An actual example is shown of the estimation of the reliability of a complex weapon system, the KC-135 Stratotanker using the explained techniques. Comparison of the predicted and measured reliability shows a large difference, with the measured reliability much higher than predicted. The managerial practices and organizational patterns associated with the performance of the reliability function are illustrated and evaluated. Use is made of the results of surveys conducted by the Navy and the Air Force, as well as a study of reliability organization at the Boeing Company. The study is concluded with an investigation into the impact of reliability engineering on the field of industrial management. Criteria for determining the need of an industrial concern for a reliability function are proposed, and possible applications to selected industries are investigated. (Author in part)

REVIEW: This dissertation gives a rather incomplete and superficial picture of the management implications of reliability engineering. Some of the reasons for this are the following:

1. There is incomplete identification of the totality of tasks normally performed by reliability engineering.

2. The treatment of reliability analysis includes elementary conventional practices which are covered in many other sources in greater detail. No insight is given into the many additional analysis concepts which are available, nor into the difficulties in their meaningful application. The large difference between the

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R E L I A B I L I T Y   A B S T R A C T S
A N D   T E C H N I C A L   R E V I E W S

predicted and measured reliability of the example system would tend to make the reader wonder about the value of this sort of analysis and of reliability engineering, particularly since the omission of reference to other reliability engineering tasks could be taken as an implication that this sort of elementary analysis is all that can be done.

3. There is little reflection of the problems and negative aspects of reliability engineering, such as its lack of acceptance by many traditional engineers and managers, and its erratic application across government contracts.

4. There is no explicit treatment of the relationship of reliability to profits, nor of the areas of incentive contracts and cost effectiveness. These would be of prime interest to management.

5. Only a few references are cited; particularly striking is the omission of the better survey/expository items in the field.

The surveys used in the work reported in this thesis have been covered previously in the literature. In fairness to the author, the difficulties of accomplishing his stated purposes must be recognized in terms of the limited resources open to the graduate student. It is encouraging to see the academic community increasing its participation and interest in the area of reliability. However, the experienced reliability manager or engineer would not feel comfortable about using this doctoral thesis to give an examination of the implications of reliability to the modern industrial management practitioner who has had little previous contact with the area. ##

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Serial Number 2344
ASQC Codes 815;863

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability requirements for reprocurement

AUTHOR: John Oliver Spencer (Maj., USAF)

SOURCE: Thesis presented to the Faculty of the School of Engineering of the Air Force Institute of Technology, Air University in partial fulfillment of the requirements for the degree of Master of Science, Aug 63, 61p, 50 refs.

PURPOSE: To determine, if possible, what part reliability considerations might play in the procurement of replenishment spares, particularly in regard to mechanical spares.

ABSTRACT: The volume of Air Force spares procurement is so great, the types of items so diversified, and the needs and benefits so variable, that this thesis is presented on a general qualitative basis rather than on a statistically analytical basis in a single area. No active program for reliability evaluation of the parts in the inventory exists in the Air Force. The major sources of failure data are the AFM 66-1 data system, Emergency Unsatisfactory Reports, user complaints, and special surveys. None of these is adequate to support a complete failure rate analysis. Surveys of material have revealed that many parts are being received which do not even pass rudimentary quality inspections. Lack of adequate specifications in contracts contribute materially to the lack of the desired level of reliability in replenishment spares. The inclusion of reliability requirements in contracts frequently results in long-range cost savings even though short-range costs are high. Approaches for improving the reliability of replenishment spares procurements are available, but procedures for practical application have not been developed. Recommendations are given, which include statistical evaluation of related costs, development of an operational phase reliability effort, and modifications of failure data reporting systems. (Author in part)

REVIEW: Input sources for this thesis were apparently a search of the literature for related material. The thesis is a readable survey relating broad reliability facets to replenishment procurements. Although nothing really new is developed, the student-author appears to have become another firm believer in the need for improved approaches to reliability considerations. As officers with this special training grow in numbers and individually progress in their careers, they will be able to do much to bring about increased applications of reliability disciplines within the Air Force. ##

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Serial Number 2345
ASQC Codes 811;813

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Managerial aspects of a generalized Air Force reliability program

AUTHOR: Donald Arthur Riess (Lt. Col., USAF, Hq. ESD (ESSKE), L. G. Hanscom Field, Bedford, Mass.)

SOURCE: Thesis presented to the Faculty of the School of Engineering of the Air Force Institute of Technology, Air University in partial fulfillment of the requirements for the degree of Master of Science, Aug 63, 45p, 27 refs.

PURPOSE: To analyze the present Air Force (AF) reliability program and to recommend those managerial philosophies and organizational principles that will insure the fulfillment of the AF reliability objectives.

ABSTRACT: Reliability is but one of many important input parameters of a system and only through systematic economic and quantitative system analysis can the best possible trade-offs be realized. Top AF management recognizes the importance of reliability and has issued clear, concise policy directives; they are identified and discussed. The Air Force Systems Command (AFSC) is delegated major responsibilities for implementing these policies. AFSC organizational structure is adequate for this task and requires little modification. However, at the lower levels where the military agencies write and administer contracts, management appears to be only half-serious about reliability. The function of reliability engineering requires skilled engineers strategically placed within the organizational structure of AFSC in order that their influences can be felt throughout the command. Commanders must afford reliability groups a proper place in the organizational structure of the AFSC division system project offices, and other line elements. (Author in part)

REVIEW: An insider's viewpoint is given here on how well AF "workers" are doing at carrying out the policies established by the top AF "bosses." The score is not very good and general AF middle management is apparently as prone as its industry counterparts to not take reliability seriously. At least some in AF management were sufficiently concerned to establish the graduate program in reliability engineering for which the student-author prepared this thesis. It is all qualitative discussion based on selected formal AF documents and on the reliability literature. The related internal AF organizational aspects are clearly presented for those who have an interest in this. ##

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ASQC Code 870

G

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Maintainability engineering guide

AUTHOR: Charles D. Cox (U. S. Army Missile Command, Redstone Arsenal, Ala.)

SOURCE: Report No. RC-S-64-1, Engineering Requirements Branch, Engineering Services Division, Directorate of Research and Development, U. S. Army Missile Command, Redstone Arsenal, Ala., 1 May 64, 135p, 22 refs.

PURPOSE: To formulate a practical method of applying, to Army missile weapons and equipment, the fundamental engineering and statistical techniques associated with the technology of maintainability.

ABSTRACT: Maintainability engineering emphasizes fast recovery of equipment in the event of failure and reductions in the upkeep cost. A separate group of specially trained engineers is normally assigned the responsibility of coordinating maintainability-enhancing inputs. Categories of maintenance are organizational (user), field, and depot; tasks of the maintenance process are described, and the relation of maintainability to system effectiveness is presented. Methods of computation, mathematical derivations, and methods of statistical testing are developed for the various maintenance indices. A maintainability program must be implemented to run concurrently with equipment design, production, and operation. Necessary organization, program tasks and criteria for maintainability design are described. Procedures are outlined for tests to demonstrate achieved downtime of electronic systems. Current military specifications pertaining to maintainability are identified. The appendices contain checklists and a sample Technical Development Plan. (Author in part)

REVIEW: Existing material was brought together to make this guide, and the author points out that little in it is new. It would be most useful for someone who is seeking orientation and a start in this area. Other references will be needed for some aspects, in particular the formulation and use of mathematical models and statistical methods for complex equipment and systems. The detailed checklists, particularly the appendices, would be helpful detail. The guides, handbooks, and manuals which are being prepared in the "...ability" areas would all benefit from more inclusion of detailed examples which proved beneficial in real applications. ##

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12/65 63N10388

Serial Number 2347
ASQC Codes 825;831;837

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability as a thermostructural design criterion

AUTHORS: F. W. Diederich, W. C. Broding, A. J. Hanawalt, and R. Sirull (Avco Corp., Research and Advanced Development Div., Wilmington, Mass.)

SOURCE: Report of work performed under Air Force Contract Nos. AF04(647)-16 and -36, Avco Corp., Research and Advanced Development Div., Wilmington, Mass., Aug 62, 44p, 7 refs.

PURPOSE: To outline a method for using a specified level of reliability as a design criterion for systems subject to a combination of environments as an alternative to the conventional approach based on combinations of safety factors for several environments.

ABSTRACT: An approach is outlined for using reliability as a design criterion for thermostructural and similar systems in lieu of sets of safety factors for combinations of various environments. The primary objective is to avoid the sometimes large, but almost invariably unknown, degree of conservatism introduced by the combination of safety factors.

Several methods are indicated for implementing this approach with emphasis on a small-perturbation method and a Monte-Carlo method. The estimation of confidence limits for the calculated reliability in terms of an implied sample size determined by the uncertainty of the available information is discussed.

The use of this approach in failure-mode analyses, reliability apportionment, and similar reliability calculations is indicated briefly. (Authors in part)

REVIEW: This report outlines a probabilistic approach to the establishment of safety factors in designing hardware. The material is clearly presented and well illustrated with numerical examples. For the design and analysis of complex systems subject to combinations of environments, the approach should constitute a useful tool. In problems of practical interest, key requirements will be (1) appropriate mathematical models for analyzing failure and (2) the necessary input statistics. No method of analysis, however sophisticated, can compensate for deficiencies in these essential ingredients. ##

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12/65 64N13646 Serial Number 2348
ASQC Code 824

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: The prediction of very-low EED firing probabilities

AUTHORS: J. N. Ayres, L. D. Hampton, and I. Kabik (U. S. Naval Ordnance Laboratory, Explosion Dynamics Div., Explosions Research Dept., White Oak, Md.)

SOURCE: NOL Technical Report 63-133, U. S. Naval Ordnance Laboratory, White Oak, Md., 4 Sep 63, 27p, 6 refs.

PURPOSE: To discuss the inadequacies of present methods for estimating low EED (electro-explosive device) firing probabilities and to propose a better procedure.

ABSTRACT: The estimation of very low EED firing probabilities is extremely important insofar as safety of weapon systems is concerned. The most widely used method, the Bruceton plan, is shown to be rather inadequate, yielding poor estimates of the required "tail" probabilities. Practical procedures for reducing errors in estimating extreme functioning probability levels are presented in terms of proper sampling, proper instrumentation, optimization of data collection procedures, and selection of proper statistical tools.

REVIEW: This is an expository report pointing out the difficulties of the most widely used procedure in this connection. Some discussion of the "no-fire", "all fire" levels is given. A reasonable, but somewhat heuristic, procedure is proposed for improving the existing method. (Another approach to estimating low probabilities may be found in the reports covered by RATR 2293.)

The first author, in a private communication, has indicated that he and his associates have broadened this work in the two papers cited below. For a better understanding of present knowledge in this area the reader should consult these papers also.

REFERENCES: [1] "Estimation of high and low probability EED functioning levels," by L. D. Hampton, J. N. Ayres, and I. Kabik, NOLTR 63-266, 3 Feb 64

[2] "Explosive safety and reliability estimates from a limited sample size," by J. N. Ayres, L. D. Hampton, and I. Kabik, presented at the Tenth Conference on the Design of Experiments in Army Research, Development and Testing, 4 Nov 64 (Proceedings to be published by U. S. Army Research Office, Durham, North Carolina, Dec 65) ##

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65 X15942

Serial Number 2349
ASQC Codes 090;716

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Results of a search for storage degradation data on component parts

AUTHOR: A. Gurnick (Philco Corp., Aeronutronic Div., Newport Beach, Calif.)

SOURCE: Aeronutronic Div., Philco Corp., Newport Beach, Calif., 5 Aug 64, 7p, 10 refs.

PURPOSE: To present the results of a search for information on aging degradation of components in long-term storage.

ABSTRACT: A search was conducted to determine what information is available on the long-term (five years and longer) storage capability of component parts. The problem of the aging of components due to calendar time is particularly important to the Shillelagh missile because of a five-year storage requirement. It was quickly determined that very little information has been published on the subject.

Component specialists obtained available data and conducted analyses on the effects of storage on materials. In performing the analyses, storage environmental limits were arbitrarily set at ambients of 0° to $+50^{\circ}C$ and 30 to 50% RH. These limits were selected because indications were that long time exposure to temperature and humidity conditions beyond these limits would very likely result in a rapid increase in degradation rate of numerous component parts and materials characteristics. In particular, components such as batteries, propellants, squibs and elastomers would be adversely affected.

Presently available information indicates that the parts, excluding propellants and squibs, used in the missile are capable of five years of storage without severe degradation if storage temperature and humidity are kept within reasonable limits (approximately those listed above) and that storage failure rates for parts will not exceed, and probably will be much less than, the operating failure rate values. Propellants and squibs are excluded pending receipt of additional data, although preliminary information suggests acceptable storage capability. (Author in part)

REVIEW: The topic dealt with in this report is important to the reliability of one-shot devices/systems which must be stored for long periods of time before use. The brevity of the report and the small number of references cited are indicative of the small amount of quantitative data in this area. The recommendations for actions to minimize potential failures and to verify storage life seem reasonable. Attacking the problem through mechanisms of failure of materials is a good idea; its implementation will require considerable time and effort. ##

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64N26025

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ASQC Codes 832;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Human reliability in the performance of maintenance

AUTHORS: Irl A. Irwin, Joel J. Levitz, and Alvyn M. Freed (Aerojet-General Corp., Liquid Rocket Operations, Sacramento 9, Calif.)

SOURCE: Report LRP 317/TDR-63-218, Aerojet-General Corporation, prepared for Ballistic Systems Div., AFSC, Los Angeles 45, Calif., Contracts AF 04(694)-424, S.A.24 and AF 04(647)-521, May 64, 65p, 20 refs.

PURPOSE: To describe a study aimed at developing a means of predicting personnel effectiveness during scheduled checkout and maintenance activities performed on the Titan II Propulsion System.

ABSTRACT: A method for estimating the reliability of maintenance performance is developed and applied to tasks involved in scheduled maintenance for Titan II engines. The approach involves the combined use of ratings and empirically derived reliability figures. A modification of the design engineer's redundancy formula is developed for estimating the increase in human reliability achieved when two mechanics work together in the performance of a single maintenance task. This study demonstrates that highly consistent ratings of task-element-reliability can be obtained from groups of qualified raters.

Plans for validating the human reliability estimates obtained during Category II testing at Vandenberg Air Force Base are described. Suggestions for further research and application of the findings are given. (Authors)

REVIEW: This is a quite detailed report of the subject study and should be of interest to those concerned with the reliability of the human element in the performance of maintenance tasks. A fairly extensive discussion of previous efforts in determining human reliability is given. This serves to place the work in proper perspective.

The authors advise caution in the application of the performance reliability estimates, as they were derived from subjective judgments and limited empirical data. The method has not been validated through the use of operational performance data. ##

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63N20733

Serial Number 2351
ASQC Codes 814;817;871;
881

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Economics of the trade-off among reliability, maintainability and supply

AUTHORS: A. S. Goldman, H. P. Kramer, W. H. Root, and T. M. Whitin (General Electric Co., TEMPO, Santa Barbara, Calif.)

SOURCE: Report RM 62TMP-42, General Electric Co., TEMPO, Santa Barbara, Calif., 30 Jun 62, 126p, 15 refs.

PURPOSE: To present techniques for dealing with the economics of choice in complex system development from a design and management viewpoint.

ABSTRACT: This and the other reports referenced in it should be considered as texts to aid in the application of economic tools to guide decisions regarding the allocation of development effort. The first part of this report presents the economic theory of choice, i.e. how, with given funds, to maximize system availability or how to minimize costs of reliability and maintainability for selected levels of availability. Emphasis is on the tradeoff issue as the basic problem. The second part deals with alternative methods of resolving the problem of choice in determining optimal combinations of reliability, maintainability, and availability on a system or less than system level of analysis. Approaches here include a system level analysis, a simulation method, and a method developed by using Boolean algebra. Results indicate that solutions to decisions faced by designers and managers involving system operational support characteristics may be practically based upon the application of well-defined economic principles. More work certainly needs to be done on this difficult problem of rational decision-making in system development. Of greatest importance is the difficult problem of estimating the cost functions. (Authors in part)

REVIEW: An unusually high tone of quality runs throughout this report. The established economic tools are nicely intertwined with the technical areas of reliability and maintainability. It definitely is applications-oriented and is readable. This report and its related referenced reports predate by some years the current nationally-organized emphasis on cost effectiveness (see RATR 1954 and 2200); they also apparently are essentially contained in the book referenced in RATR 2312. ##

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12/65 65N19355 Serial Number 2352 -1
ASQC Codes 810;871

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Handbook for reliability and maintainability monitors

AUTHORS: G. H. Allen; J. R. Barton, Maj., USAF; R. M. DeMilia; G. Grippo, Capt., USAF; and J. E. Horowitz (Technical Requirements and Standards Office, Electronic Systems Div., Air Force Systems Command, USAF, L. G. Hanscom Field, Bedford, Mass.)

SOURCE: Technical Documentary Report No. ESD-TDR-64-616, Technical Requirements and Standards Office, Electronic Systems Div., AFSC, USAF, L. G. Hanscom Field, Bedford, Mass., Dec 64, 279p (AD-611 577)

PURPOSE: To provide a single, readily-available reference covering USAF AFSC ESD reliability and maintainability (R/M) policy.

ABSTRACT: Each section of this handbook deals with a facet of R/M which is a potential or actual ESD problem. Items which bidders must discuss in proposals are, e.g., R/M predictions, design review, program tasks, and organization. A single R/M plan, the "Availability Program Plan" should be submitted. Guidelines for each item are presented. A framework for various reliability decision-making techniques is developed to provide a rationale for choosing appropriate statistical accept/reject criteria. Steps to be taken and points to be checked by the program R/M monitor are outlined from definition through acquisition phases. Twelve problems with contractor practices are identified, including poor design-reviews, isolated R/M Groups, incorrect models, predictions not updated, and no corrective action follow-up. Several technical problems that arise in developing reliability incentives, and some suggested solutions are identified.

REVIEW: Much of this report is general philosophy which would be helpful only to newcomers. It is largely reliability with little material on maintainability. The handbook presents material on an idealized type of reliability and maintainability program which in reality is seldom supported by the procuring agency or implemented by the contractor. Some of the specifics are the strongest features, such as detailed checklists in the design review section and illustrations of actual contractor problems. The handbook suffers mainly from poor editing; it would be distracting to someone not already familiar with the contents. For example, two lengthy sections (V and VI) are virtually on the same subject: reliability measurement in the AGREE sense. Attachment 1 of both these sections constitute almost identical discussions of the basic laws of probability. Similar material on reliability measurement shows up in Sections I and IX. The last column of the chart on page 4 of the Appendix to Section VII is labeled exponential mean life. The life distributions of parallel configurations are not exponential when those of the elements are exponential. Hence, this column is labeled

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

incorrectly. Almost no references are cited throughout the handbook.

The first author, in a private communication, has pointed out that this TDR was not intended to be a complete and final text, but is simply an unedited collection of lectures presented during 1963 to various mission organizations at ESD. This was mentioned also in the handbook itself and accounts for some of the points mentioned above. However, the criticisms are given here to assist potential readers in deciding whether or not they wish to pursue this material. A more accurate title for this document would perhaps have been "A Collection of Papers on Reliability." ##

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12/65 63X13077 Serial Number 2353
ASQC Codes 814;872

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Criteria for discard-at-failure maintenance

AUTHOR: Eugene G. Wrieden (IBM Corporation, Federal Systems Div., Space Guidance Center, Owego, N. Y.)

SOURCE: Final Report RADC-TDR-63-140, prepared for Rome Air Development Center, Research and Technology Div., AFSC, USAF, Griffiss Air Force Base, N. Y., by IBM Corporation, Federal Systems Div., Space Guidance Center, Owego, N. Y., Contract No. AF30(602)2681, Mar 63, 94p, 42 refs.

PURPOSE: To describe the results obtained by studying the major factors influencing the feasibility of the discard-at-failure maintenance (DAFM) concept.

ABSTRACT: Earlier studies have established that DAFM is feasible; this study was needed to develop a mathematical model which describes the influence of the major factors affecting the feasibility of the DAFM concept on the total resource cost of discard and repairable modules. Requirements for the model were (1) simplicity and ease of use, (2) general applicability to electronics, and (3) applicability during early design phase. Major factors affecting DAFM are reliability, population and cost of the module, of distribution, of repair, and of entering and maintaining a line item in the supply system. A detailed description is given of the mathematical model developed under this study, which at the most general level is the difference between repair and discard costs. The model becomes more complex as the variables and constants are introduced. A step-by-step procedure is presented of a simplified method of application in order to obtain a usable model. Microminiaturization will force some form of DAFM, and this form of model can help define the optimum module size. The model was applied to numerous hypothetical cases; ratios of predicted maintenance costs to initial equipment costs ranged from 3 to 8 which agrees with published figures. A field evaluation program to establish model validity could not be performed under this study. Application and use of the model may uncover further simplification possibilities such as computerization and graphical methods. (Author in part)

REVIEW: Another applications-oriented reference on throw-away maintenance is nicely presented by this report. It does not purport to have the final word, but would be useful to anyone contemplating the incorporation of discard-at-failure into a design. The bibliography contains numerous applicable references. It would be interesting if a survey were made to establish the extent to which discard-at-failure is actually being applied in new designs. RATR 2300 is on the same subject, but from the naval viewpoint. ##

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12/65 65N85810 Serial Number 2354
ASQC Codes 821;871;872

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Maintainability prediction: theoretical basis and practical approach (Revised)

AUTHORS: George Harrison, Harald Leuba, and Eli Schneider (ARINC Research Corp., 1700 K Street, N.W., Washington, D. C. 20006)

SOURCE: ARINC Research Publication No. 267-02-6-420, prepared for Aeronautical Systems Div., USAF under Contract AF 33(657)-10594, 31 Dec 63, 128p also 66X81744

PURPOSE: To present a revised version of an earlier maintainability prediction technique.

ABSTRACT: The theory behind the maintainability prediction technique is summarized. Several refinements are made to the technique presented in [1], the most significant being a method for the prediction of initial delay. This method permits prediction of the distribution of total system down time due to malfunctioning equipment. It uses measurable aspects of the equipment to predict the probability of occurrence of certain elemental activities. These are the detailed activities such as gaining access or interpreting meter readings within the broader categories of preparation or fault location. The probabilities and the observed times required for the performance of elemental activities are combined to produce the larger categories of maintenance time, and finally a distribution of total system down time. The technique, developed for airborne electronics equipment, is applicable primarily to equipments and systems used under the Air Force general maintenance policy and only at the flight-line level. However, the research approach and the basic relationships developed should provide for a degree of general application. Sample predictions are made for several systems, and the results of some verification studies are included. A step-by-step procedure for predicting total system down time is presented. A computer program is included for automating the maintainability prediction procedure; it is written in Fortran language for an IBM 1401 computer. (Authors in part)

REFERENCE: [1] Anthony Drummond, George T. Harrison, and Harald R. Leuba, "Maintainability Prediction: Theoretical Basis and Practical Approach", ARINC Research Corporation Publication No. 207-1-275, 15 Feb 62

REVIEW: Considerable detail is presented here but none of it is superfluous. The results are from a series of related studies and thus have survived some scrutiny. This is a readable and well-illustrated report which will be a useful reference to those performing maintainability predictions. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Notes, Fifth Workshop on Maintainability, EIA

AUTHOR: W. R. Downs (Douglas Aircraft Co., Inc., Missile & Space Systems Div., Santa Monica, Calif.)

SOURCE: Douglas Report SM-45273 (a compilation of notes taken at the Fifth Workshop on Maintainability sponsored by the Electronic Industries Association in St. Louis, Mo., May 64), 21 Aug 64, 115p

PURPOSE: To foster a better understanding of maintainability and its importance to the conceptual design and development of new Douglas products.

ABSTRACT: Trip reports from the Douglas Company representation at the Fifth Workshop on Maintainability sponsored by the EIA are consolidated to provide a reference document. This is an interim in-house report pending receipt of the formal proceedings. Discussion in the organizational workshop indicated the need for a high level management policy but agreed that the maintainability function could be in any number of organizational locations. A large problem is the lack of interface between other "...abilities." Some proposal-oriented questions are answered, on such specifics as incentive contracting and proposal detail. Currently-established maintainability prediction techniques are identified. It is desirable to have a single military specification on maintainability, and this program is under way. Many questions pertaining to design reviews remain unanswered, including the use of checklists and finding a measure of compliance. None of the attendees in the Test and Evaluation session had actually completed a maintainability demonstration under WR-30, XW-30, or MIL-M-26512. Notes are also included on design guidance, training, and trade-offs. Appendices cover exhibits, attendee list, MIL-STD-778, a checklist, and a specification list.

REVIEW: This informal manner of documenting conference proceedings has the advantages of timeliness and of identifying the problems and solutions as related to the company involved. It is to be encouraged. State of the art of maintainability is reflected here. Many sources of further detail are sprinkled throughout these notes. An overall reaction is that a lot of thrashing around is occurring in organizing maintainability, but, as with reliability and other "...abilities," there is truly a need for improvement and occasionally a government program office will become serious about the subject and a strong contractor capability will pay off. The formal meeting report is contained in Maintainability Bulletin No. 4, available from EIA Engineering Department, 11 West 42nd Street, New York 36, New York. ##

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12/65 65N21319 Serial Number 2356 -1
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Analysis of specification systems for the procurement of high-reliability parts

AUTHOR: Bryce Sigmon (ARINC Research Corp., 1700 K Street, N.W., Washington, D. C., 20006)

SOURCE: ARINC Research Publication No. 304-01-1-435, Final Report prepared under Contract No. NASw-831 for Office of Reliability and Quality Assurance, NASA, Washington, D. C. 20546, May 64, 73p

PURPOSE: To present a qualitative analysis of six specification systems for the procurement of high-reliability parts.

ABSTRACT: In recent years procurement specifications for military parts have increased the controls over materials, the manufacturing operation, and the testing of parts. At present there is no concerted effort among consumers with high-reliability requirements to standardize or consolidate their specification procedures, causing penalties in cost and delivery schedules. The concept of line qualification has the potential for minimizing the undesirable aspects of part procurement that are attributable to qualification based on specific part types. Line qualification would qualify a manufacturer to produce a class of parts on a single production line, resulting in reduced costs and delivery times plus allowing a steady production rate. The six specification systems which are analyzed are: MIL-R-38100, MIL-S-19500, MIL-M-23700, NPC-200-3, NASA/UTC, and Lockheed (system for high-reliability devices.) The analysis procedure is described. The specifications are rated numerically for the factors of cost, delivery time, and reliability on each of 90 subjects which are pertinent to the particular specification. Examples of the 90 subjects are reliability assurance plan, yield, application data, date code, solder, and environmental testing. No rating is given if the specification provides no requirement in the factor or subject. Brief discussion is given on the scope and meaning of the 90 subjects. Flow charts for qualification and acceptance testing of the specifications are shown as appendices. (Author in part)

REVIEW: The detailed analysis is thorough and would be of high interest to persons concerned with the specification of high-reliability parts. Line qualification as proposed here is currently used to some extent on the specification of passive parts such as resistors and capacitors, where an entire generic type with different functional characteristics and physical sizes is covered by a single specification and qualification test. This concept deserves study for further extensions. In using the detailed ratings of the six specification systems it should be kept in mind that the omission of a rating on a subject means that the particular specification

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had nothing on the subject. This is not necessarily a neutral situation, as some of the subjects omitted will often be of high importance. Also, another cautionary note is that a good parts specification is not a sufficient guarantee that all requirements and tests are fulfilled. Many different disciplines in addition to that of preparing the specification--such as purchasing, sales, manufacturing, testing, and quality control--are involved in the process that actually results in a delivered part. Variations in the knowledge and goals of this diversity of persons too often results in a large gap between what a specification says and what actually exists. This report is disconcerting to the reader because of difficulty in obtaining initial orientation. The introduction does not explicitly introduce the body of the report; there are no explicit conclusions or summaries, and the concept of line qualification is covered only in the introduction. ##

Serial Number 2357
ASQC Codes 512;553;822

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Component's life evaluation and reliability (CLEAR)

AUTHOR: K. E. Ryan (North American Aviation, Inc., Space and Information Systems Div., Downey, Calif.)

SOURCE: Report SID 65-5, North American Aviation, Inc., Space and Information Systems Div., Contract No. NAS7-200, 5 Jan 65, 31p

PURPOSE: To derive some relationships useful in estimating confidence in reliability demonstration based on the Weibull distribution, and to present a set of tables covering a family of Weibull distributions for use in reliability engineering.

ABSTRACT: Using the Weibull function with scale parameter α and shape parameter β, an expression is written for reliability R(T), where T denotes a test time. Treating R(T) as the parameter of a binomial distribution, and assuming zero failures, an expression is obtained for a confidence C in terms of R(T) and n, the number of items being tested. After some algebraic manipulation and the introduction of certain simplifying assumptions, expressions are obtained for (1) T in terms of C, β, n, and R(t), where t denotes mission time, (2) n in terms of T, β, C, and R(t), and (3) α in terms of R(t). It is indicated that expression (1) may be used to compute the test time required to demonstrate a reliability R, at confidence C, with n items, based on a Weibull distribution with shape parameter β, expression (2) may be used to compute the number of items required to demonstrate a reliability R with confidence C and test time T, based on the same Weibull distribution. The third relation is useful in studying distributions whose hazard functions are linear or approximately linear. It is shown that the number of cycles necessary to demonstrate a given reliability R with confidence C decreases as β increases if all other factors remain constant. Thus the exponential distribution (β = 1) can be considered as a "middle of the road" distribution from a test time standpoint. Tables giving test time, α value, and first moment of the distribution for various values of R, β, C, and n are presented. An illustration of their use is given.

REVIEW: From one step to the next, the mathematical manipulation in this paper fits together satisfactorily. However, for the reader who wishes to follow precisely what is done, it is less than satisfactory from the conceptual viewpoint. For example, the reader is left to infer or guess what the author means by "confidence C." (It is, apparently, the confidence coefficient associated with a lower confidence limit on reliability.) That is to say, more careful discussion would have been necessary to establish the validity of the process and to make the reader aware of just what he would be doing in using these results. ##

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12/65 65N17605 Serial Number 2358
ASQC Code 838

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Analysis and development of failure-responsive system organizations

AUTHOR: C. G. Masters, Jr. (The Westinghouse Electric Corp., Electronics Div., Box 1897, Baltimore, Md., 31203)

SOURCE: Technical Report No. 5, Contract NASw-572, Reference WGD-38521, The Westinghouse Electric Corp., Electronics Div., Box 1897, Baltimore, Md., 31203, Dec 64, 68p, 13 refs.

PURPOSE: To report on the development of a new technique for more effectively employing redundant equipment to increase the useful life of electronic digital systems.

ABSTRACT: Most of the methods for employing redundant equipment to improve reliability restrict the operation of redundant components or subsystems to a single location within the overall system. This report presents a technique which allows redundant subsystems to be shifted around within a system in response to the existing failure pattern. The techniques for analyzing fixed redundant systems are not generally suitable for failure-responsive systems. For the latter a computer simulation method is proposed. The details of the program are presented, and the results obtained from its use are given in the form of curves. From the curves it is concluded that (1) the capability of individual subsystems to move to new locations should be as evenly distributed among the subsystems as possible, (2) the subsystems which are available for use as spares to any two stages should be chosen so that the mutual dependence by these stages on the same spares is minimized, and (3) the systems should be so organized that, in normal circumstances, a subsystem will not move to the aid of a critically failed stage if its movement will leave the stage in which it is presently operating vulnerable to a single failure. It is further concluded that the beneficial effects obtained from failure-responsive capability more than offset the disadvantages inherent in the relatively complicated circuitry required for its implementation. The optimum number of spare subsystems for any stage is a function of the failure rate of the peripheral circuitry relative to the failure rate of the subsystems.

REVIEW: This study represents a worthwhile contribution to the literature on redundancy as a device for improving system reliability. It points to the general conclusion that failure-responsive systems employ redundancy more effectively than do fixed-redundant systems. It should be noted, however, that the study pertains to a particular class of digital systems, i.e., those composed of homogeneous subsystems. This limits the usefulness of the technique, since few actual digital systems have this property. ##

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12/65 65N25639

Serial Number 2359
ASQC Codes 711;712;815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Fatigue in actuators

AUTHORS: R. E. Little and C. Bacgi (Mechanical Engineering Dept., Oklahoma State University, Stillwater, Okla.)

SOURCE: Final Report prepared for Oklahoma City Air Materiel Area, Tinker Air Force Base, Okla., under Contract AF 34(601)-17361, Oklahoma State University, Mechanical Engineering Dept., 1964, 6p (AD-612 904; CFSTI: HC $1.00/MF $0.50)

PURPOSE: To propose changes in MIL-C-5503B to mitigate fatigue problems in actuators.

ABSTRACT: Actuators have not been properly designed to withstand fatigue; consequently, fatigue failure will increase with time unless a significant preventive program is begun. It is clear that MIL-C-5503B, 7 March 1956 is outdated and should be revised. Positive suggestions are made for such improvements. The specification presently has no acceptance paragraph relevant to fatigue. The major factor involved in reducing the number of fatigue failures in actuators is the elimination of unnecessary stress concentrators and the reduction of the stress concentration effect of ports, fillets, grooves, etc. Three other sources of failure are the following. (1) It is apparently common practice to elevate the loading requirements placed on existing actuators with little if any actuator modifications. (2) Certain manufacturing defects still pass inspection and acceptance tests. These defects should be tabulated on the master drawing supplied the vendor and more rigorous inspection techniques should be developed to circumvent these problems. Feedback is the key factor in eliminating manufacturing problems. (3) Secondary modes of failure such as corrosion or stress corrosion should also be called out on the master drawing, viz., certain exposed areas should be labeled as "stress-corrosion critical." (Authors in part)

REVIEW: If we could only do as well as we now know how, many of our reliability problems would simply disappear. This problem is serious in many fields. Top DoD management must become aware of these problems and realize their importance. Next, the proper procedures must be included in Mil Specs and contracts. Finally, the design and production engineers must know what to do and do it. The problems are not really technical; that is what makes them so sad.

The first author, in a private communication, has mentioned that the details of certain parts of their stress analyses were published in "Stress Analyses of Pressurized Cylinders," Engineering Research Bulletin 145, Oklahoma State University, March 1965. ##

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12/65 65N22212 Serial Number 2360
ASQC Codes 711;714

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Corrosion as a problem to the Air Force

AUTHOR: Robert C. Drebelbis (Lt. Colonel, USAF, The RAND Corporation, Santa Monica, Calif.)

SOURCE: Presented at the AF Logistics Command Commanders' Conf., San Antonio, Tex., 12 Mar 65, 7p (AD-611 877)

PURPOSE: To describe corrosion as an escalating problem to the United States Air Force.

ABSTRACT: From the beginning of time corrosion has been a military problem. Even though it has been a persistent problem, it is only in the last decade that corrosion has become a serious and costly problem to the Air Force. Early vintage aircraft were built of nearly pure aluminum and with an excess margin of safety. Conversely, our current high-performance aircraft are engineered to exact design tolerances and any change or deterioration of the designed structure is costly in equipment, man-hours, and lives. Corrosion is also a more severe problem in the high-stressed high-strength alloys of today.

Corrosion is oxidation as a direct result of electrolytic action destroying the boundary layer between the granular structure of metal. The three prerequisites of corrosion are: (1) unprotected metal, (2) an ionic conductor, and (3) water, or a medium for electron flow. The many forms of corrosion may be classified into four principal categories: exfoliation, pit, intergranular, and stress. It is emphasized that corrosion differs from metal fatigue which is identified by cross-granular cracking.

Design and production specifications prescribe reliable corrosion controls, but cost cutting practices eliminate these protective measures. The ultimate result is not cost-effective, but pound-foolish, costing the Air Force dearly in time, money and lives.

REVIEW: This is the sort of problem that plagues the reliability engineer. It is widespread. The cures are well known and reasonable, yet engineers, customers, and manufacturers make the same mistakes repeatedly. How to prove these facts to top management and sell cost-effectiveness is a real challenge. ##

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12/65

65N22977

Serial Number 2361
ASQC Code 844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Procedure for the analysis of semiconductor failures

AUTHOR: R. D. Solberg (Sandia Corp., Electronic Components Div., Albuquerque, N. Mex.)

SOURCE: Report SC-RR-65-137, Sandia Corp., Electronic Components Div., Albuquerque, N. Mex., Apr 65, 11p (CFSTI: $1.00)

PURPOSE: To describe the most efficient failure-analysis procedures to be followed.

ABSTRACT: As semiconductors become smaller in size and more complex in structure, analysis of failed devices becomes even more important in the reliability of semiconductors. Many failures such as burned post leads, broken bonds, and other obvious visual defects do not require extensive analysis. However, many failures are very difficult to detect and the causes of such failures require even more consideration in reaching a conclusion. Degraded units pose many more problems than the catastrophic failures since these units usually have some crystal defect which is often very hard to detect even after sectioning and etching. Obviously, degraded failures require very precise information on the past history of the devices and the processes involved in the manufacture of the units.

After finding the failure (if possible), the problem lies in determining the cause of the located failure. Was the device loaded beyond its specifications or did the unit have a defect which caused the failure? Thus, more often than not, it is very difficult to detect whether the unit or the circuit was at fault.

A set procedure of analysis can be used to establish patterns of failure and thus allow more detailed study on the exceptions to the known patterns of failure. Without a well-defined procedure, not only may the real reason for failure be obscured but incorrect conclusions may lead to much wasted effort or even to a decrease in reliability. First the units are tested electrically to see what parameters are out of tolerance. After a visual inspection and/or X-ray analysis the can is opened and further microscopic inspection is made. Metallurgical sectioning and examination may be necessary. This type of analysis may also serve as a valuable background for the development of reliability screen techniques for semiconductor devices. (Author in part)

REVIEW: The general description of the techniques here is good. There is considerable detail on the metallurgical sectioning and examination of specimens. These techniques need considerable practice before a laboratory becomes efficient with them. The photographs in the photocopied report are poorly reproduced. ##

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65N19156

Serial Number 2362
ASQC Codes 720;813;850

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: U. S. Army advancement in transistor reliability through manufacturing process improvements

AUTHORS: E. B. Hakim and B. Reich (United States Army Electronics Command, Fort Monmouth, N. J.)

SOURCE: Technical Report ECOM-2472, U. S. Army Electronics Laboratories, U. S. Army Electronics Command, Fort Monmouth, N. J., Nov 64, 12p (AD-610 956)
IEEE Transactions on Reliability, vol. R-14, p. 94-99, Oct 65

PURPOSE: To summarize the improvements in transistor life due to the Production Engineering Measures program.

ABSTRACT: This report outlines transistor reliability improvements achieved by semiconductor manufacturers who incorporated improved processing techniques into their lines. These advancements were achieved under the project known as the Production Engineering Measures program for transistor reliability improvement.

The procedures reported upon include the status of reliability of the particular devices used in the program (in most cases the entire family of devices); the methods such as accelerated testing of monitoring relative improvements; and mention of the advanced techniques such as diffusion, metalization, lead bonding, packaging, and photoresist which contributed to the improvement. Failure rates were lowered by factors of 10 to 1000. (Authors in part)

REVIEW: This was a very important program of product improvement. One would hope that some manufacturers do this on their own and that this type of process improvement will continue. Perhaps one benefit of having the government pay for this work is that the improved methods and techniques are not proprietary. They can then be widely distributed and used to upgrade the entire industry. ##

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12/65 65N21524

Serial Number 2363
ASQC Codes 711;712

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Determining fatigue limits by testing one sample

AUTHOR: V. Simek

SOURCE: Strojirenstvi (Czechoslovakian), Vol. 14, No. 3, 1964, p. 216-222, Translation prepared by Translation Div., Foreign Technology Div., WP-AFB, O., FTD-TT-64-1009/1+2, 24 Mar 65, 15p

PURPOSE: To describe a method for determining the fatigue limit by testing a single sample.

ABSTRACT: This is essentially the staircase or step-stress method, wherein the stress is gradually increased until failure occurs. The fatigue limit is calculated as follows. Estimate three possible S-N curves and calculate the cumulative damage for the specimen with each curve in turn, according to Miner's linear damage theory. Plot the fatigue limit for each curve against the total damage calculated for the specimen. Extrapolate (or interpolate) this curve to unity damage and read off the fatigue limit. An example is given. Accuracy of ± 10% is claimed.

REVIEW: This is an unedited translation and reads accordingly. The median fatigue limit is undoubtedly meant when fatigue limit is used. Obviously the success depends on good guesses at typical SN curves. In the absence of other information, the guess obtained in this way is better than nothing. Probably, more than 3 SN curves should be used in order to avoid extrapolation and to get an idea of the minimum uncertainty involved. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Optimizing electronic weapon system effectiveness

AUTHORS: Stanley A. Rosenthal (Kollsman Instrument Corp., Syosset, N. Y.) and Irwin Nathan (General Precision, Inc., Wayne, N. J.)

SOURCE: Journal of the Electronics Division, American Society for Quality Control, vol. 2, Jun 64, p. 3-18

PURPOSE: To discuss a model for system effectiveness.

ABSTRACT: Weapon system effectiveness may be defined as the ratio of the statistically determined probable number of target area hits to the maximum possible number of target area hits, within a specified time after a command to fire has been issued, for a system operating in a prescribed manner with a specified maintenance policy.

Weapon system effectiveness is optimized by "trading-off" between the reliability, maintainability and accuracy parameters of the system. Included in this optimization process is the establishment of an availability ratio. It is within this ratio that the analytic model relating maintenance and reliability is defined.

A probabilistic availability model for a relatively uncomplicated, but nevertheless realistic, electronic weapon system is derived with emphasis on the basic assumptions. The resulting model is discussed in the light of its role as a major factor in the determination of weapon system effectiveness, including consideration of a practical approach to the estimation of mean-time-to-repair.

A method for optimizing the effectiveness is then discussed for the conditions when system accuracy is independent of time, and when system accuracy is a function of time between data inputs or calibrations. (Authors in part)

REVIEW: The paper contains long equations; following it through exactly will be time-consuming. However, that is what must be done if the results are to be used. The assumptions are well stated except for the equation for system effectiveness; therein, all the events of which the probabilities are listed are presumed to be statistically independent--an assumption which should be subjected to verification in practical situations. The parameter d which appears in some equations is not defined. However, the author in a private communication has indicated that the symbol d was a typographical error--it should be replaced with b wherever it appears. (The algebra was not checked in detail but appears to be good.) ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Exponential distribution analysis of corrective maintenance times

AUTHOR: James W. Creson (Philco Corp., a Subsidiary of Ford Motor Co., Western Development Laboratories, Palo Alto, Calif.)

SOURCE: Journal of the Electronics Division, American Society for Quality Control, vol. 2, Jun 64, p. 19-29, 6 refs.

PURPOSE: To show that the exponential assumption is satisfactory for certain data.

ABSTRACT: This paper applies an exponential distribution to the analysis of corrective-maintenance-time data from a satellite tracking station. The data are analyzed using Kolmogorov-Smirnov, chi-square, and rms tests. Results show that a distribution hypothesis may be accepted at a 95 percent confidence level. The exponential distribution is unreservedly recommended as a replacement for log-normal analysis whenever possible. (Author)

REVIEW: The data do appear to fit an exponential distribution. The recommendation in the abstract does not really mean much, since naturally one would use a model which fits the data. If several distributions appear to fit equally well, one would choose the simplest one that has a reasonable a priori basis.

The author, in a private communication, has commented as follows: "The review essentially makes the point that I wanted made: that simplicity in analysis is desirable. I would, however, strengthen my recommendation now, in view of the more than two years that have elapsed since preparation of the original paper. In addition to the equipment reported in the ASQC Journal, I have analyzed maintenance time data from some dozen subsystems (as a ROM estimate, 1000 data points), representing a complete spectrum of tracking station equipment. All data were tractable under exponential analysis."

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Serial Number 2366
ASQC Code 820

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Some aspects of reliability and life testing

AUTHOR: H. Leon Harter (Aerospace Research Laboratories, Wright-Patterson Air Force Base, O.)

SOURCE: Journal of the Electronics Division, American Society for Quality Control, vol. 3, Sep 64, p. 5-14, 13 refs.

PURPOSE: To give a brief review of mathematical models for use in the analysis of reliability and life-test data.

ABSTRACT: The laws of probability are briefly described and applied to redundant systems. The Poisson and exponential distributions are explained and examples are given of their use. Methods of estimating the single parameter of each distribution are given. A model for reliability growth is derived.

REVIEW: The material in this paper appears to be generally accurate and well presented. Much of it is rather elementary and has appeared in many places before. There are some difficulties, however; for example, the term "independent" is used to mean statistical independence which is not the same thing as physical independence. The formulas for redundancy are generally true only if there is but one possible environmental profile. The failure rate and hazard rate are usually not defined to be the same. It should be pointed out that non-linear functions of unbiased estimates are usually biased. For example, if the estimate of mean time-to-failure in the exponential distribution is unbiased, the corresponding estimates of reliability and of failure rate based on this estimate are biased. For an excellent expository treatment of truncated sequential life tests based on the exponential distribution see the paper covered by RATR 1854. ##

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G

Serial Number 2367
ASQC Code 711

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Valve corrosion

AUTHORS: (Staff feature)

SOURCE: Materials Protection, vol. 4, Jun 65, p. 28-32, 34, 35

PURPOSE: To give case histories of valve corrosion.

ABSTRACT: Fourteen case histories of valve corrosion problems are given; each explains what caused the failure and how the problem was solved. Several types of valves are included: gate, safety relief, plug, and ball. Valve services involve steam, dry chlorine gas, acetic acid, sulfuric acid, hydrogen fluoride, chlorides, and river water. Materials discussed include stainless steels (18-8, 316, and 304), carbon steel, cast iron, chrome plated carbon steel, titanium, and a nickel-molybdenum. Valves, like pumps and other pieces of process equipment, must be designed and specified for corrosion resistance not only to the material being handled but also the environment. This is particularly true of a process stream which becomes highly corrosive when mixed with air or water, as happens on valve stems when the packing fails or when gaskets give way. Often, when a valve corrosion problem is encountered, the natural reaction is to specify one of the exceptional metals that usually have high resistance to corrosion. Unless such a specification is first verified by corrosion testing or checked against previous experience records, the more expensive materials may not be the answer at all.

Although these high alloy materials can solve many difficult corrosion problems, selection of a more expensive alloy or metal does not assure that a good application will result. These materials must be specified for valve service with good engineering discretion and with the realization that they are subject to the same corrosion effects as the more common and less expensive materials of construction. (Authors in part)

REVIEW: This is a good article for designers of hardware to read. Obviously some of the cautions and experiences apply to parts other than valves. High reliability requires infinite attention to detail. This takes time and money in advance. Often, enough of either is not available, or is not considered worthwhile. ##

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Serial Number 2368
ASQC Codes 833;870

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Dual filters increase aircraft reliability

AUTHOR: Donald B. Meredith (The Boeing Co., Airplane Div., Renton, Wash.)

SOURCE: Hydraulics & Pneumatics, vol. 17, Feb 64, p. 68-70

PURPOSE: To show how a new filter improved system life.

ABSTRACT: Engine - driven pumps are the most common hydraulic system failures. Usually a system will have a 10-micron filter with a bypass set so that the filter is bypassed during high flows. If a failure that generates harmful metal particles occurs during this time, the pump gets contaminated. The other pump then is also contaminated and probably damaged.

The new filter has two elements. Up to 7 gpm both filters are in the system (fine one first.) Above that flow, only the "coarse" one is included. If the pressure drop exceeds 400 psi (never in normal service) that filter, too, is bypassed. The fine filter is a disposable element 0.4 micron rating; the coarse one is a 1.5 micron cleanable element.

A field test definitely indicated the superiority of this new filter.

REVIEW: This is an example of a nominal product improvement which really turned out to be an improvement. This is the sort of engineering attention to detail that is necessary for high system reliability.

As mentioned in the paper covered by RATR 1881, the use of cleanable elements presents problems in maintenance which are not easy to overcome. ##

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G

Serial Number 2369
ASQC Codes 716;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Reliability facts and factors--accelerated testing*

AUTHOR: Robert A. Yereance (Battelle Memorial Institute, Columbus, O.)

SOURCE: Systems Design, vol. 9, Jun 65, p. 3-5 (*based largely on work by Ralph E. Thomas of Battelle, which is reported in more detail in numerous documents by Mr. Thomas; see, for example, RATR 163, 1407, and 1666.)

PURPOSE: To present a brief expository discussion of accelerated testing.

ABSTRACT: The most common stress to use for acceleration purposes is temperature. Only two basic problems are unique to accelerated testing:

1. It must be ascertained that the degradation mechanisms which predominate under accelerated testing are the same mechanisms that predominate under use conditions.

2. An expression must be found which relates life (or other pertinent characteristics) at use conditions to life at the elevated stress conditions. Ideally a simple time-multiplier, or acceleration factor, is sought.

In testing component parts, acceleration factors of 10 are sometimes possible, factors of 2 are usually possible. High acceleration factors (10 to 10,000) should be viewed with suspicion as they generally hold only between those two conditions of stress (accelerated and use), for which they have been validated. The Arrhenius and Eyring rate equations for temperature effects are discussed. (Author in part)

REVIEW: This is a brief introductory article. The cautions quoted in the ABSTRACT above are especially worthwhile. It should be pointed out that not all chemical reactions follow the rate equations given in the text. ##

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Serial Number 2370
ASQC Code 815

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: EEE specifying guide: resistors

AUTHOR: Stephen E. Scrupski

SOURCE: EEE, the magazine of Circuit Design Engineering (formerly Electronic Equipment Engineering), vol. 12, Dec 64, p. 34-39

PURPOSE: To help to specify resistors.

ABSTRACT: Reliability, cost, and size are three important properties of resistors. Insofar as cost is concerned, it is system overall cost that is important, not part cost. Sometimes a more expensive resistor (e.g., close tolerance) can make the system less complicated. The change in resistance from nominal or original value is the only consideration (except at very high frequencies); so the life problem is one of keeping the resistance changes within proper bounds. Remember that there are reversible and irreversible changes and that they can be due to many, many causes--check on them all. Some may be correlated, some not--but use the proper formulas for combining changes. Do not confuse initial precision with stability or temperature coefficient. In a failure rate specification, always check the conditions of test and the definition of failure, whether it was a field or lab test, and also check the statistical analysis. Screening tests are available to improve the reliability.

REVIEW: This is generally a good article; proper cautions are given about the required attention to detail. The cliché that "reliability is never inspected in ..." is repeated and is true up to a point. Screening tests, however, are an example of inspecting unreliability out of a product. On systems especially, much unreliability can be inspected out.

Combining tolerances should be done carefully; remember that whereas the resistor knows how much it may change, your calculation is only an attempt to estimate it. Thus using the root square variation just because the answer is smaller is not good practice. If the variations are uncorrelated, then the total variance (σ^2) is just the sum of the individual variances (σ_i^2); if there are correlations, and there well may be--as in a voltage divider for example--then get statistical assistance. The distributions need not be Gaussian (Normal) for combining variances, contrary to the text. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Designing redundant analog amplifiers

AUTHOR: T. B. Hooker (General Electric, Missile and Space Division, Spacecraft Department, Valley Forge Space Technology Center)

SOURCE: EEE, the magazine of Circuit Design Engineering (formerly Electronic Equipment Engineering), vol. 13, Feb 65, p. 54-59

PURPOSE: To explain active and passive redundancy for ac and dc amplifiers.

ABSTRACT: Analog redundancy falls into two general categories--active redundancy and passive redundancy. Active redundancy involves a switching between alternate identical circuits when a failure mode is detected. Passive redundancy refers to the use of series, parallel, or series-parallel (quad) combinations of component parts or circuits to enhance the probability of success of the combination. In active redundancy there must be some means of sensing the failure and then switching over to the alternate amplifier. Several means are available such as putting in an extra high frequency signal and checking its relative output. Several examples are given. A reliability improvement factor is defined as $RIF = (I-R_{amplifier})/(1-R_{system})$. This is 48 for one example.

Passive redundancy is also possible in several ways. For example, one can combine the inputs and combine the outputs in such a way that the gain of a single ac amplifier is realized as long as at least one is operating properly. The best configuration to use will depend on the kind of amplifier (e.g., high gain), where it is used, whether it is ac or dc, and on the consequences of particular failures.

REVIEW: This discussion is concerned essentially with the catastrophic failure of parts in the amplifiers. It is rather complete and should be useful to designers. A voting type redundancy (it picks the middle value of three signals) is explained in the paper covered by RATR 2159. Reliability calculations are given only for passive redundancy. In active redundancy it should be remembered that de-energized components still see the same physical environment and thus their failure rate is not zero; the failure probability of the switching device must also be considered--this was not done in the examples. Negative feedback is a well-known way of increasing drift reliability without redundancy per se. Table III, referred to in the Conclusions seems to be missing.

The statistical independence assumption is made implicitly. This is a strong assumption and implies, among other things, that the environmental profile is known exactly. If several environments are possible, then the failure events cannot be statistically independent. ##

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64A18223

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Automatic evaluation of fixed resistor reliability under simulated panclimatic conditions

AUTHORS: G. W. A. Dummer, C. H. Miller, and L. Edwards (Royal Radar Establishment, Malvern, England)

SOURCE: Proceedings of the Institution of Electrical Engineers, vol. 111, p. 36-42, Jan 64

(+ Electronics Record ?)

PURPOSE: To describe resistor evaluation equipment.

ABSTRACT: This paper describes the design and construction of a machine for testing resistors and records the results of the considerable number of tests made to date. The equipment does not accelerate any existing test procedure, but makes it possible to test, automatically, batches of 1000 resistors to any sequence of climatic cycles within the following ranges:

temperature	$-70^{o}C$ to $+ 100^{o}C$
voltage loading	up to 1kv (a.c. or d.c.)
humidity	up to 100% r.h.

Endurance tests of 2000 hours' duration can be carried out according to any prearranged code of instructions.

The resistance of each individual test specimen can be measured automatically at any period during a climatic or power-load sequence as required. All resistance measurements are plotted as percentage variations from nominal value, and are carried out at controlled conditions of $+20^{o}C$, 75% r.h. The equipment has been used to evaluate 38 batches (27,500 resistors), and a summary of these results is included.

Satisfactory operation over a long period, together with the large number of resistors it has been possible to test, confirm the usefulness of the equipment as a possible aid towards the evaluation of resistor reliability. (Authors in part)

REVIEW: The test equipment appears to serve its purpose well. It is, however, important to note the authors' final thought, also given in the ABSTRACT above, "...a possible aid towards the evaluation of resistor reliability." Many other kinds of tests and evaluations must be made to ensure high reliability. ##

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ASQC Codes 814;831

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Electronic system reliability--an American viewpoint

AUTHOR: P. S. Darnell (Bell Telephone Laboratories, Inc., Whippany, N. J.)

SOURCE: Proceedings of the Institution of Electrical Engineers, vol. 111, p. 284-290, Feb 64 ("Electronics Board")

PURPOSE: To present an overall view of reliability.

ABSTRACT: In the military picture some 10 to 12 years ago, it was becoming apparent that equipment was getting more and more complicated. Much of this equipment was inoperable much of the time; it required huge stocks of spares and considerable time to maintain; but most important, at least so it appeared, it should be considerably more reliable than it was. Reliability looked like a panacea to cure all these ills about a decade ago. Today there is not only reliability, but also maintainability, human engineering, value engineering, project-evaluation programs, etc. However, the need for improvement will not be satisfied until one of these specialties takes over the responsibility of demonstrating to the user that he is getting equipment suitable for his needs, at the lowest possible cost. It is convenient to define an adequate system as the lowest total-cost system that will do what the user expects it to do whenever called upon. For practical purposes these days, total annual ownership costs go down as component failure rates go down.

During evolution of a system, its reliability and availability must be calculated, evaluated, and improved at many stages. Each time there is a transition from one group to another up the line toward manufacture and use, new problems will arise and need to be solved. Environmental engineering plays a large role in reliability. In order to test adequately, the actual environment must be known and properly simulated. The process of trouble reporting and failure analysis should begin early and continue into final use. (Author in part)

REVIEW: As the author undoubtedly realizes, his concept of an adequate system embodies the essence of engineering. Due to the limitations of human ability, engineering is split into many factions so that at least one faction can be mastered. Reliability, of course, is one of these--just one part of good engineering. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Service life of materials working with stress relaxation

AUTHORS: L. P. Nikitina (I. I. Polzunov Central Scientific Research Institute for Boilers and Turbines)

SOURCE: Industrial Laboratory, vol. 29, p. 1495-1499, Apr 64 (Translated from Zavodskaya Laboratoriya, vol. 29, p. 1344-1347, Nov 63)

PURPOSE: To present a method using long-term strength data for assessing the service life of a material under conditions of stress relaxation.

ABSTRACT: Relaxation tests were carried out using cylindrical specimens of EI415 steel and EI607A nickel alloy on UIM-5 machines. Plastic strain was accumulated by stress relaxation, and the original stress was restored by a periodic application of additional load. The relaxation curves were plotted, the strains were recorded, and the plastic strains accumulated during each relaxation cycle were calculated.

Under conditions of stress relaxation, specimen failure occurs when the deformation ability of material is exceeded in the presence of an increased stress. Furthermore, the curve representing accumulation of plastic strain during stress relaxation is similar to the primary creep curve.

Service life under stress relaxation conditions can be assessed by the calculation of a mean apparent stress which can be related to long-term strength data.

REVIEW: This article is a translation from the Russian, and as such is somewhat difficult to read. It is brief and to the point. While it does not contain many useful graphs or tabulations of data, it is a worthwhile contribution. ##

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Serial Number 2375
ASQC Codes 712;716;774;
844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: On methods of fatigue testing at high temperatures

AUTHORS: S. V. Serensen and L. A. Kozlov

SOURCE: Industrial Laboratory, vol. 29, p. 1514-1519, 9 refs., Apr 64 (Translated from Zavodskaya Laboratoriya, vol. 29, p. 1359-1365, Nov 63)

PURPOSE: To discuss special features of the fatigue strength of materials and the methods of fatigue testing at high temperatures.

ABSTRACT: High temperature fatigue tests, in comparison to room temperature fatigue tests, impose additional requirements on the conditions of the tests. Some of the factors which must be taken into consideration are: loading frequency, rigidity of loading, creep, and kinetics of the stressed condition in relation to elastic-plastic strain.

A general discussion of the various effects associated with structural changes, surface conditions, oxidation, test frequency, imperfect elasticity, stress concentration factors, asymmetry of load, and unsteady loading on high temperature fatigue tests are presented. Recommendations for minimizing effects from these factors are also included. Scatter in high temperature fatigue test data is comparable to that observed in room temperature fatigue data; therefore, in general, cumulative damage and statistical analysis techniques which are applicable to room temperature fatigue data can be used for high temperature fatigue data.

Fatigue failures at high temperatures are closely linked with surface phenomena. High temperature initiation and propagation of rupture is less localized than room temperature rupture. The initiation occurs at several points; the cracks join and spread; and final rupture occurs along grain boundaries.

REVIEW: This is a translation from the Russian which is quite easy to read. The material basically is not original with the authors or new. The article would be of value to the uninformed or the inexperienced. But, to the seasoned materials engineer or researcher, the material is most probably common knowledge. ##

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Serial Number 2376
ASQC Codes 712;844

RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Comparison of fatigue mechanisms in bcc iron and fcc metals

AUTHORS: W. A. Wood, W. H. Reimann (University of Melbourne, Metallurgy Dept., Victoria, Australia), and K. R. Sargant (Aeronautical Research Laboratories, Dept. of Supply, Melbourne, Australia)

SOURCE: Transactions of the Metallurgical Society of AIME, vol. 230, p. 511-518, 11 refs., Apr 64

PURPOSE: To identify basic mechanisms of fatigue in bcc metals and to determine why they give contrastingly different S/N curves from those shown by fcc metals.

ABSTRACT: Tests to reconcile the observed differences in the S/N curves of bcc and fcc metals were carried out using Armco and pure iron in comparison with O.F.H.C. copper and 85/15 brass. Microstructural changes resulting from alternating torsional tests of annealed and electropolished specimens were observed in order to identify mechanisms of fatigue.

For the bcc metals, fatigue damage above the knee of the S/N curve resulted primarily from abnormal strains arising from pronounced cell formation in the grains. A secondary effect resulting from impurities was also observed. The cell boundaries are virtually fault boundaries which grow into microcracks. As the amplitude is decreased through the knee of the S/N curve, a dispersion of fine slip is observed. This fine slip results in dispersed pores within grains and, in some cases, along grain boundaries. The latter condition illustrates fatigue in its least detrimental form. Fcc metals must pass through a stage where slip and pores are canalized, potentially dangerous, before they can reach the harmless condition of dispersed slip and pores. This intermediate state accounts for the difference in the shape of the S/N curves for the bcc and fcc materials.

The intermediate state may be absent in the bcc structure because of the numerous slip systems and the relatively easy cross slip. Both backward and forward slip would tend to occur in the bcc structure until it was forced to disperse because of local hardening.

REVIEW: The work reported in this paper is most interesting and thought-provoking. It is doubtful that a design engineer would find the paper useful; however, the research engineer or physicist studying mechanisms of fatigue and the physics of failure would find it to be a useful reference.

While the authors' theories may be controversial, they are a worthy contribution to the published literature in this field. ##

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RELIABILITY ABSTRACTS AND TECHNICAL REVIEWS

TITLE: Modern views of the fatigue processes in metals

AUTHOR: A. J. Kennedy (College of Aeronautics, Dept. of Materials, Cranfield, Bletchley, Bucks, England)

SOURCE: British Journal of Applied Physics, vol. 15, p. 229-234, 13 refs., Mar 64

PURPOSE: To review fundamental fatigue processes in metals.

ABSTRACT: A synopsis of fatigue research from its beginning and a detailed summary of the more modern views of fatigue are presented. Some of the modern ideas are:

1. Dislocation behavior resulting from alternating stress,
2. Characteristics and modes of fatigue crack initiation and propagation,
3. The concepts of high and low stress fatigue, and
4. The influence on properties of physical changes induced by alternating stresses.

Fatigue damage can be considered as the initiation of slip bands resulting from alternating dislocation slip in combination with local cross slip which causes the development of fissures. Fissures can be explained by current dislocation theory. In general, recent advances in fatigue research have resulted from separation and a clear identification of old ideas rather than new theories. More work, however, is required before the processes of fatigue can be generalized further.

REVIEW: This article will be more informative to those in research than to design engineers. It is an excellent, easily-readable, general discussion of the fundamental concepts of fatigue; therefore, it should be most useful as a primer to the uninformed or partially informed. ##

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